REPUBLIC OF KENYA

BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR CLIMATE CHANGE TECHNOLOGIES MITIGATION

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Supported by:

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This report has assessed the technology needs for climate change mitigation in Kenya. The report has further prioritized technology needs for mitigation within the energy and waste management sectors using a multi-stakeholder process and a linear additive Multiple Criteria Analysis Framework. A Barrier Analysis and Enabling Framework for the prioritized technologies have been done and measures identified to overcome these barriers. Finally, Technology Action Plans and Project Concepts have been developed. It is my sincere hope that these 4 part report findings will prompt all stakeholders to take timely action in climate change mitigation and that the reports will form an important reference tool to spur all actors to implement the prioritized technologies in order to contribute in addressing climate change in Kenya.

PROF. GEOFFREY WAHUNGU
DIRECTOR GENERAL, NEMA

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LIST OF ACRONYMS

CBA	Cost Benefit analysis
CFLs	Compact Fluorescent Lamps
CAN	Calcium Ammonium Nitrate
CNA	Climate Network Africa
EIA	Environment Impact Assessment
EMCA	Environmental Management and Coordination Act
GHG	Greenhouse Gas
IISD	International Institute for sustainable Development
IPCC	Intergovernmental Panel on Climate
KAM	Kenya Association of Manufacturers
KCJ	Kenya Ceramic Jiko
KEDIP	Kenya Domestic Biogas Programme
KENGEN	Kenya Electricity Generating Company
KEPSA	Kenya Private Sector Alliance
KIPPRA	Kenya Institute for Public Policy Research and Analysis
MDGs	Millennium Development Goals
NGOs	Non-Governmental Organisations
NPV	Net Present Value
R&D	Research and Development
SREP	Scaling Up Renewable Energy Programme
SHS	Solar Home System
TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax

EXECUTIVE SUMMARY

The report on Barrier Analysis and Enabling Framework starts with description of the preliminary targets for technology transfer and diffusion in the prioritized technologies in the energy and waste management sectors. These technologies include Solar Home Systems and Solar Dryers in the energy sector and Methane Capture from household bio-digesters in the waste management sector. The targets in the Solar Home Systems (SHS) comprise end-users of the SHS who comprise mostly rural households, schools, colleges and government institutions. The targets for Solar Dryers technology include commercial farmers, small scale farmers, tea processing factories, vegetable processors, cooperatives societies and associations and family units. The target groups for Methane Capture for household bio-digesters comprise rural farmers, institutions and commercial enterprises.

Barriers for SHS and Solar Dryer in the energy sector and barriers for Methane Capture from household bio-digesters in the waste sector were identified. The barriers were identified from a variety of sources. These include:

i) Desk study of policy papers and other pertinent documents
ii) Consultants own experience
iii) Economic and other relevant assessments
iv) Brainstorming sessions in workshops with stakeholders
v) Expert and stakeholder consultations
vi) Generic barriers as identified in the TNA Guide Book
vii) Market mapping tool

Barrier identification was conducted with full participation of the stakeholders. Identified barriers in the energy and waste management sectors were screened and analyzed. After analysis, barriers were grouped into two main barriers: economic and financial and non-economic and financial barriers.

Other barrier categories (specific) include: economic and financial; market failures; network failures; institutional and organizational capacity; human skills; social, cultural and behavioral; information and awareness; and technical.

After analysis, main barriers for each prioritized technologies in the energy and waste sectors were identified and decomposed. Using logical problem analysis tool, problem trees were created and all problems were arranged around a starter problem/barrier. All identified problems were ordered in a hierarchy of cause-effect relations with starter problem in the centre and the direct causes below it and direct effects above.

In order to transfer and diffuse renewable technologies in the energy and waste management sectors, measures to overcome barriers in the prioritized technologies were identified. These Measures were identified from the following sources:

i) Desk study of policy paper and other pertinent documents
ii) TNA consultants own experience
iii) Measures already touched on during the barrier analysis
iv) Measures identified in the TNA Handbook
v) Market Mapping Tool
vi) Logical problem analysis (objective tree)
vii) Market maps for each prioritized technology

Identification of measures was done with full participation of stakeholders. Identified measures to facilitate transfer and diffusion of prioritized technologies in the energy and waste management sectors were analyzed and classified into main categories. These are economic and financial measures and non-economic and financial measures. The measures were further disaggregated into specific measures which are similar to the category barriers mentioned above.
Logical problem analysis tool was used to identify measures to overcome barriers for prioritized technologies in the energy and waste sectors. This was done by reformulating the problem tree

created during barrier analysis. All problems (barriers) identified in the problem tree became positive statements about a future situation in which barriers for SHS, Solar Dryers in the energy sector and Methane Capture from household bio-digesters in the waste sector were solved. The cause effect relations of the problem tree were converted into measure result relation.

Linkages of different barriers faced by Solar Home Systems and Solar dryer technologies in the energy sector were analyze so as to maximize synergies and optimize the effects of recommended measures. In the waste management sectors, linkages of different barriers were not done since, only one technology in the sector was retained.

An overall strategy for overcoming barriers for the energy and waste management sectors was formulated. An enabling framework was presented at two levels. The first level addresses the common measures of the prioritized technologies for the energy sector, while the second level is specific to Solar Home Systems and Solar Dryer technologies in the energy sector.

Solar Home Systems

Main Barrier	Measures
Economic and Financial High Initial Investment	Setting up of local assembling Industries for PV and SHS parts and components and enhancing R& D for solar PV and SHS technologies
High cost of solar panels and batteries	Setting up of local assembling industries for solar panels and batteries.
Lack of subsidies on SHS components	Remove VAT on solar batteries and other SHS components. Currently VAT exemptions applies to complete SHS package as opposed to single component
High cost of installation	Establishment of focused training programme for solar PV and SHS technicians
High Interest rates	Land funds to viable renewable energy projects on concessional rates under the future Green Energy Fund Facility
Non- Economic/ Financial Inadequate Information and awareness	Conduct adequate information and awareness campaigns through print and electronic media
Lack of Research and development	Initiate research and development activities SHS through public and private sector partnership
Weak regulatory framework	Strengthen regulatory framework

Solar Dryer

Main Barrier	Measure
Economic and Financial High up- front cost	Setting up of local assembling industries for solar dryer parts and components and enhancing R& D for Solar Dryer
High interest rates	Land funds to viable renewable energy projects on concessional rates under the future Green Energy Fund facility
Non- Economic/ Financial Inadequate information and awareness	Conduct adequate information and awareness campaigns through print and electronic media
Inadequate skilled personnel	Establish critical mass of locally trained personnel
Inadequate policy, legal and Regulatory framework	Formulate enabling Policy, Legal and regulatory framework for solar dryer technology

Methane Capture

Economic/ Financial High cost of construction of bio-digesters	Remove duty and other taxes on all imported components for construction of bio-digesters
High Interest rates	Lend funds to viable renewable energy projects on concessional rates under the future Green Energy Fund
Non- Economic/ Financial Lack of skilled technical personnel	Provision of customized training courses for technicians to undertake construction and maintenance of bio-digesters
Low awareness of benefits of bio-digesters as sources of reliable and clean energy	Conduct public awareness campaigns on benefits of bio-digesters in both print and electronic media.
Lack of market links	Develop market links within households and between households and technology

1. ENERGY SECTOR

1.1 Preliminary Targets for Technology Transfer and Diffusion for SHS and Solar dryer technologies

The preliminary targets for the transfer and diffusion of solar home systems low carbon emission technology include end users of the solar home systems (SHS) technology. These include mainly rural households and institutions not connected to the grid. Less than 20% of the total population and 5% of the rural population (about 1.6 million households) in Kenya have access to electricity (World Bank, 2009). As mobile technology becomes a part of Kenyan culture and Nairobi positions itself as the technology hub of East Africa, demand is growing fast for electricity from both on- and off-grid consumers. Evidence of this includes frequent rolling blackouts due to insufficient supply and the growing popularity of off-grid solutions such as small-scale (20 Watt panels) solar home systems. About 165,000 SHS units are targeted annually for installation from 2013 to 2030 translating to 3 million units by 2030. About 80% of the Kenyan population have no access to electricity from the grid (6 million rural households). The target for SHS technology therefore is 50% of the 6 million households i.e. 3 million households by 2020. Other targets comprise mostly rural based institutions such as schools, hospitals, dispensaries, prisons and government offices. It is noted that even those households which are already connected to the grid may wish to have an alternative and more reliable power supply such as SHS due to frequent power outages.

According to https://energypedia.info/index.php/Kenya_Country_Situation, an estimated 200,000 rural households in Kenya have solar home systems and annual PV sales in Kenya are between 25,000-30,000 PV modules. Majority are 14-20 Watts panels for domestic usage. According to Helio International (2009), the installed photovoltaic systems generate 9GWh of electricity annually primarily for lighting and powering television sets. It is estimated that about 30,000 SHS will be sold annually.

The preliminary targets for Solar Dryer technology and include the following: commercial farmers and companies (1000); cooperatives societies and associations (100) and family units (50,000) and tea processing factories (65). It is estimated that the number of commercial farmers using solar dryers technology will double by 2030 will be 20,000.

Table 1.1 below shows trade and production of solar PV and SHS parts and components between 2004 and 2008.

Table 1.1: Trade and Production of Solar PV Parts and Components in Kenya Mean (2004-2008)

Short Description	Units	Imports	Production	Consumption
Instantaneous or storage water heaters, Non-electric-other [e.g. Solar Water Heaters]	Number	2,813	-	1,492
Static converters [e.g. rectifiers and inductors and inverters for converting dc power to ac power]	Number	305,995	-	305,690
Photovoltaic system controller [charge controller for voltage not exceeding 1000 V]	Number	185,171	-	114,113
Photovoltaic cells, Modules and Panels	Number	118,322	-	112,908
Other lead-acid accumulators [Deep discharge (solar)	Number	173,740	<50,000	1112,015

Source: KIPPRA 2009

1.2 Barrier Analysis and Possible Enabling Measures for Solar Home Systems (SHS)

1.2.1 General Description of Technology: Solar Home Systems

Solar electricity is the electric power generated from sunlight using devices called *solar cell modules*. Electric devices transform solar energy into electricity for lighting, pumping water powering radios, televisions etc.

Kenya lies along the Equator. Solar energy resources are available in many areas of the country in quantities that are commercially viable. In addition, small scale systems for households and institutions such as schools, hospitals especially in isolated rural areas not connected to the grid can be developed for local community utilization.
Solar Home Systems provide (SHS) provide households lights, and electrical power for televisions, cassette players and small appliances.

Some of the benefits of SHS include the following:

- Employment creation
- Better health as opposed to use of paraffin lamps and candles. Traditionally families in rural areas use paraffin lamps and candles as source of light. These lamps and candles produce fumes which are harmful to human health
- SHS reduce significantly risks of fire when they replace kerosene lamps and candles
- Good learning opportunities for students in the evenings
- SHS can replace use of fossil fuel for energy generation. The mitigation potential is in the range of 1,000ktCO_2 /year in2030 (IISD (2012)).

1.2.2 Identification of Barriers for Technology: SHS

Barrier Identification is defined as the process of tracing reasons that hinder the transfer and diffusion of SHS technology. This includes the following:

- Identification of any failed or missing measures that could have sustained the transfer and diffusion of the SHS technology
- Understanding the nature of individual barriers
- Understanding the relationship between individual barriers
- Determining the important barriers and identify barriers that are easiest to remove

The following process was used to identify barriers for SHS technology

i) A desk study of policy papers and other pertinent documents
ii) Economic and other relevant assessments of the SHS technology were included in the desk study
iii) Workshop by technology working groups and which included a brainstorming session. This workshop was held on 25th July 2012 at Laico Hotel, Nairobi (See Annex IV)
iv) Expert and stakeholder consultation (one on one basis)
v) Reference to checklist of generic barriers as identified on Annex A of the TNA Guidebook
vi) Market mapping tool-consumer goods and capital goods. The elements in the market environment and the relation to the market chain were used to identify barriers for SHS.

Market mapping
The first step is to map the actors who directly take part in the consumer chain for PV systems from consumer to importation or production of the product and to establish the flow of money between them. The market for small scale PV systems in Kenya can be divided into three different segments i) SHS systems for individual consumers ii) Solar PV systems for institutions such as schools, health centres and administrative buildings and iii) Solar PV systems for water pumping. Each market segment faces different market barriers. In the case of SHS, a substantial part of the equipment used is currently procured by service providers, such as utilities, NGOs or energy service companies (ESCOs).These companies constitute a special market segment with special access to funding. Over time it is expected that a larger share of PV systems will be sold directly to consumers.

The next level in the market chain comprises retailers and wholesalers of solar panels, batteries and whole systems. Local production or assembling of batteries and solar panels can ensure local employment and products of lower costs. Production of solar cells (wafers) is normally produced in large quantities in highly specialised factories. These are imported and become parts of the assembled panels. Importers of wafers are shown in Annex IA at the right along with importers of solar PV panels and manufacturers of local batteries.

Market mapping was conducted in consultation with stakeholders using group discussions. This led the groups through a common understanding of the market for SHS and its possible constraints.

The barriers identified using market map for the Solar PV and SHS market chain (Annex IA) and other approaches are shown below.

- High costs of solar panels and batteries
- Few skilled persons to install and maintain the systems
- Availability of low quality systems (Solar PV systems, batteries, inverters) in the market.
- Insecurity – stealing of solar panels and batteries
- Gap between existing legislation and actual implementation
- Low enforcement of standards
- Inadequate information and awareness of the potential benefits of the SHS
- Inadequate policy for SHS
- Lack of subsidies
- High Costs of Installation, Repair and Maintenance
- Weak currency
- Theft of solar panels and batteries
- Exchange rate fluctuations
- Inadequate Public private partnerships
- High interest rates on loans
- Few manufacturers of solar batteries (only one in the country)
- Few distribution networks
- Inadequate R&D and unfocused training
- Poverty- Low affordability amongst rural and peri-urban dwellers
- Bureaucracy
- Transiting procedures
- No specific law to regulate the management of renewable energy sub-sectors; specifically solar energy

Barrier Analysis and Categories

After barriers were identified, they were screened according to their significance. After screening the barriers for SHS, the following categories were identified.

Table 1.2 below shows barrier categories.

Table 1.2: Barrier Categories

Barrier	Category
High interest rates on loans	Economic and financial
Inadequate Public private partnerships	Institutional
Exchange rate fluctuations	Economic and financial
High Costs of Installation, Repair and Maintenance	Economic and financial
Weak currency	Economic and financial
Lack of subsidies	Economic and financial
Few skilled persons to install and maintain the systems	Human skills
Few distribution networks	Network failure
High cost of solar panels and batteries	Economic and financial
Theft of solar panels and batteries	Economic and financial/Social, cultural, behavioural
Availability of low quality systems (Solar PV systems, batteries, inverters) in the market	Policy, legal and regulatory
Inadequate policy for SHS	Policy, legal, regulatory
Gap between existing legislation and actual implementation	Policy, legal, regulatory
Low enforcement of standards	Policy, legal, regulatory
Inadequate information and awareness of the potential benefits of the SHS	Information and awareness
Insecurity	Economic and Financial
Few manufacturers of solar batteries (only one in the country)	Policy, legal, regulatory
Inadequate R&D and unfocused training	Technical
Bureaucracy	Policy, legal, regulatory
Poverty- Low affordability amongst rural and peri-urban dwellers	Economic and financial
No specific law to regulate the management of renewable energy sub-sectors; specifically solar energy	Policy, legal, regulatory
Transiting procedures	Policy, legal, regulatory

1.2.2.1 Economic and Financial Barriers

The following are the economic and financial barriers to transfer and diffusion of SHS low carbon emission technology:

i) High Initial Investment Costs

SHS face several economic and financial barriers. These are barriers which make SHS to require high initial investment costs. These barriers include the following.

Most of SHS parts and components such as solar photovoltaic cells, solar modules and panels, charge controllers, compact fluorescent lamps (CFLs)and solar batteries are imported. However, there is a local company in Kenya which also manufactures solar batteries including car batteries. High technology involved and raw materials required for solar PV and SHS are also expensive. A complete SHS including wiring and installation charges amounts to about US$ 2,000. The price of CFLs ranges between US$ 2.5 to US$ 5.6 (8 to 20 watts).

iii) Lack of Subsidies on SHS components

The government of Kenya does not provide subsidies for one to purchase a SHS. Due to relative high costs of SHS, this has made the SHS to be inaccessible to the rural poor households which this technology is targeting.

iv) High Costs of Installation, Repair and Maintenance

There are no institutions in the country providing focused and practical training courses on design, manufacturing/production of static converters, photovoltaic system controllers, photovoltaic cells and modules in the country. These are skills necessary for installation, repair and maintenance of SHS. Technical colleges and other tertiary institutions offer general courses on electronics and electrical engineering. As a result, hands on skills are limited. Due to scarcity of trained local personnel to repair and maintain SHS, the costs of Solar PV and SHS are relatively high.

v) High Interest Rates

Financial institutions charge interest rates ranging between 15% and 30% for people wishing to get loans. The same interest rates are applicable to those wishing to access loans to purchase SHS.

1.2.2.2 Non Financial Barriers

i) Inadequate Information and Awareness

The majority of Kenyans living in rural areas have little information concerning the potential social, economic and environmental benefits of the SHS. Little information and awareness on SHS is due to the fact that neither the government nor the private sector has committed financial resources to use both the print and electronic media to provide information and at the same time publicize the importance and potential benefits of SHS to the public at large.

ii) Theft of Solar Panels and Batteries

Over 45% of Kenya's live below poverty line surviving on less than US$ 2 per day. As a result of high unemployment rates and poverty, some people are inclined to steal solar panels and batteries to sell in order to make extra income.

iii) Lack of Research and Development (R&D) and Unfocused Training

Neither the private sector nor the government has committed adequate resources for R&D for solar PV and SHS. As a result, other than the solar batteries some of which are locally produced most of the solar PV and SHS components are imported. As a consequence there is limited technical human personnel for installation, repair and maintenance of SHS.

iv) Limited Number of Local Technical Trained Personnel (engineers and Technicians)

Local Universities and other tertiary institutions in the country offer courses on electronics. These courses are theoretical in nature and do not focus on design and application of specific technologies such as photovoltaic (PV). As a result, the country has limited number of trained technical personnel to install, repair and maintain SHS in the country.

v) Few Distribution Networks

There are few distribution networks for SHS countrywide. As a result, SHS customers have to travel long distances to buy the system.

vi) Low Quality Standards for SHS

Due to inadequate legal and regulatory framework and corruption, low quality solar panels, batteries and compact fluorescent lights (CFLs) end up in the country. Low quality solar panels are unreliable and breakdown shortly after installation while low quality CFLs also last for a short duration after being fixed. These low quality SHS products are sold at lower prices to unsuspecting customers.

vii) Weak Regulatory Framework
The Kenya Bureau of Standards (KBS) has established standards for solar panels, solar batteries, CFLs, inverters and wiring systems. However, due to weak regulatory framework, these standards are rarely enforced.

viii) Corruption
Low quality solar panels and compact fluorescent lights (CFLs) destined for other countries end up in the Kenya market. This is can be attributed to corruption at the point of entry and weak enforcement of SHS standards in the country.

After barrier analysis, the starter/problem *barrier was identified as "*Solar Home Systems Require High Initial Capital Investment Costs" as shown on table 1.3 below. This barrier was decomposed as follows:

Table 1.3: Decomposition of Barriers

Category of Barriers	**Barriers within a Category**	**Elements of Barriers**	**Dimension of Barrier Elements**
Economic and Financial	SHS Require high initial capital investment costs	High cost of solar panels and batteries	• Lack of subsidies • High Interest Rates • Lack of information and awareness • Few distribution networks
Non-Economic Barriers		Theft of solar panels and batteries	• Poverty
		Lack of R&D and unfocused training	• Limited number of local trained personnel • High Costs of Installation, Repair and Maintenance
		Low quality standards of SHS	• Weak regulatory framework • Corruption

Logical Problem Analysis was used as a tool in the analysis of the starter barrier for SHS i.e. Solar Home systems require high initial capital costs. This method `was used to identify the root cause of the barriers in the SHS in which case all problems/barriers were arranged around a starter problem. All identified problems were ordered in a hierarchy of cause-effect relations with starter problem in the centre and the direct causes below it and direct effects above. The problem tree includes screened barriers which were decomposed in close consultation with the stakeholders. Annex IIA shows a problem tree for SHS indicating causes and effects. The main barriers for SHS technology are located at the bottom of the problem tree.

1.2.3 Process of Identifying Measures

Barriers of Measures

i) A desk study of policy papers and other pertinent documents
ii) Workshop by technology working groups and which included a brainstorming session. This workshop was held on 25th July 2012 at Laico Hotel, Nairobi (See Annex IV)
iii) Expert and stakeholder consultation (one on one basis)
iv) Market mapping tool-consumer goods and capital goods. The elements in the market environment and the relation to the market chain were used to identify barriers for SHS.

The following measures to promote transfer and diffusion of SHS were identified by the stakeholders.

1.2.3.1 Economic and Financial Measures

SHS will become affordable through a combination of both economic and financial measures and non- financial measures. These measures are discussed below.

i) Low costs for solar PV and SHS parts and components will be realized by encouraging the private sector to establish industries locally. This can be complemented by enhanced R&D for solar PV and SHS technology.
ii) The government in collaboration with the private sector can provide subsidies such as free CFLs to Kenyan households as a measure aimed at phasing out incandescent bulbs as well as promoting diffusion of SHS. This measure was piloted by the government in collaboration with Kenya Power Company in 2010 whereby households exchanged incandescent bulbs with CFLs. Remove VAT on SHS batteries and components. Currently VAT exempted applies to complete SHS package as opposed to buying single units.
iii) The government of Kenya in collaboration with the development partners is in the process of starting a Green Fund Facility whereby investors in green energy can access loans on concessionary rates. It is expected that the government will operationalize this fund soon.
iv) The government is setting up a Green Energy Fund Facility under the National Taskforce on Accelerated Development of Green Energy and whose purpose is to lend funds to viable renewable energy projects on concessional rates.
v) It is expected that establishment of focused training programmes for solar PV and SHS will result in existence of critical mass of technicians in the country to undertake activities such as installation, repair and maintenance of SHs. This is likely to result in low costs for installation, repair and maintenance of SHS.

1.2.3.2 Non-Financial Measures

i) Through Public Private Partnerships (PPPs), the private sector in collaboration with the government and NGOs will avail resources to conduct adequate and effective public information an awareness campaign thro' print and electronic media.
ii) The private sector, local universities and the Kenya Industrial Research and Development Institute (KIRDI) will initiate R&D activities in the area of solar PV and SHS. Funding for R&D activities will be provided by the government and private sector through PPPs, NGOs and development.
iii) Local Universities and other tertiary institutions in the country will be encouraged to offer practical training courses on solar PV and SHS electronics with emphasis on design and application of solar photovoltaic cells, modules and panels. As a result, the country will have a critical pool of trained technical personnel to install, repair and maintain SHS in the country.
iv) In order to increase diffusion of SHS in the country, SHS distributors/retailers will be encouraged to increase their distribution networks by making sure that these products are available within the mobility range of potential customers, typically less than 40km from the customers home.

v) Diversification of livelihoods will be encouraged in all the forty seven counties in the country in order to create wealth. Agro-processing to increase crop value addition is one example of enhancing the livelihoods of small scale farmers.

vi) The Kenya Bureau of Standards has developed national standards for solar PV and SHS. The government will ensure that these standards are enforced through strengthening of the regulatory framework and reduction of corruption.

vii) Loopholes which enable transit SHS destined for other countries in the region to end up in Kenya will be sealed. This will be done through collaboration between the Kenya Bureau of Standards and the Immigration Department.

1.2.3.3 Enabling Framework

In order to build on success of over 200,000 SHS installations country wide, the government of Kenya has done the following:

- **Finance Policy**
  Through the Finance Policy, the government has zero rated import duty on solar photovoltaic cells, modules and panels and also removed VAT on imported and locally produced solar batteries, SHS parts and components. At present time VAT is exempted only when one buys a complete SHS package. There is need therefore to remove VAT on SHS individual components.
- **Introduction of Scaling-up Renewable Energy Program (SREP)**
  This program will support Kenya's initiative towards achieving transformational changes that will lead towards low GHG emissions development pathway by harnessing the abundant renewable energy sources such as solar energy and especially SHS.
- **The Energy Act 2006**.
  The Energy Act (2006) established the Energy Regulatory Commission whose function among others is to enforce and review regulations, codes and standards for the energy sector. The Energy Act has substantially reformed the Energy Sector with an effective institutional, regulatory and legal framework The energy Act does not specifically address SHS technology and in this regard it needs to be reviewed to address SHS technology given its potential impact on rural development.
- **Sessional paper no. 4 of 2004 (The energy policy document).**
  This policy framework aims at promoting development of energy for industrial, commercial and domestic use. It lays special emphasis on development of renewable energy But still requires to be renewed to articulate issues of SHS technology.
- **Green Energy Fund**
  The government is setting up a Green Energy Fund Facility under the National Taskforce on Accelerated Development of Green Energy and whose purpose is to lend funds to viable renewable energy projects including SHS on concessional rates.

1.2.4 Cost Benefit analysis for Solar Home Systems (SHS

$$\text{NPV} = \sum \frac{\text{Net Benefit}_t}{(1+i)^t}$$

Net Benefit = Benefit - costs
NPV = Net Present Value
t = year
i = Discount rate

Cost Benefit Analysis (CBA) is a technique for assessing the monetary costs and benefits of implementing a technology over a given time period.
The following principles are relevant for CBA.

i) It can show whether it is feasible or not and acceptable to transfer and diffusion of a particular technology
ii) It includes externalities such as social/environmental impacts and 'private' economic costs and benefits so that externalities are incorporated into the decision making process
iii) Can take account of the economics of time (discounting)

Benefits (Avoided medical costs, Time saved, Usage of electrical appliances TV/radio)
Population = 1000 people

It is estimated that about half of 1000 people suffer from Upper Respiratory Diseases (UPRD) and poor eye sight due to indoor air pollution associated with use of fuel-wood for cooking and many hours using kerosene lamps/candles for lighting (students using kerosene lamps/candles for reading are mostly affected) = 500
Cost of travelling to hospital= KShs.200/-
Cost of medicine/person = Kshs.300/-
Total cost (travelling cost of medicine)/person =Kshs.200/-+Kshs.300/-= Kshs.500/-
Cost for 12 trips/yr. = KShs.500 x 12
= Kshs. 6000/-
Total cost for 500 people = KShs. 500*6000=Kshs. 3,000,000/-
Cost of time saved = KShs.4000/day x 500 people x 12 days/year
= Kshs. 24 million
Total = KShs.27 million

Benefit of using electrical appliances

i) 4 batteries @ KShs. 30 x 12 months x 1000 people =KShs. 360,000
ii) Aesthetic Value = KShs. 500/yr. x 1000 people
= KShs. 500,000
Total = KShs. 860,000

iii) Value of all the Benefits = KShs. 27 million
+ KShs. 860,000/-

KShs. 27,860,000/-

Cost of avoided paraffin per household of 5 people i.e. 2 litres of kerosene/household/week
Cost of paraffin = 84 KShs. /litre
iv) Cost of avoided paraffin/year = 2 x 52 x 200 x 84 KShs. /litre
=KShs. 1,747,200 million
Total Benefits (iii) + (iv) =KShs. 28,747,200/-

Unit Cost of SHS technology (4 lighting bulbs, Radio/TV) = KShs. 30,000
Target = 1000 households (each household has on average 5 members)
v) Cost of Technology = 30,000 x 200 people
= KShs. 6,000,000
Net Benefit (iv)-(v) = 28,747,200 – KShs. 6,000,000
=Kshs.22, 747,200/-
Cost of 1 US Dollar = KShs. 84/-
= 22,747,200/ 84
Net benefit in US Dollars = US$ 270,800
Discount rate i= 8% = 0.08
Time, t = 1 yr.

$$\text{NPV in US \$} = \frac{270,800}{(1+i)^t}$$

$$\frac{270{,}800}{(1 + 0.08)^{1}}$$

NPV in US $ =250,740.74 for 1st year

Similar calculations were done for the next nine years and the results are presented in table 1.4 below

Table 1.4: NPV for SHS

Year	Calculation	PV (US$)
1	$270{,}800/(1+0.08)^1$	250,741
2	$270{,}800/(1+0.08)^2$	232,167
3	$270{,}800/(1+0.08)^3$	214,970
4	$270{,}800/(1+0.08)^4$	199,046
5	$270{,}800/(1+0.08)^5$	184,302
6	$270{,}800/(1+0.08)^6$	170,650
7	$270{,}800/(1+0.08)^7$	158,009
8	$270{,}800/(1+0.08)^8$	146,305
9	$270{,}800/(1+0.08)^9$	135,467
10	$270{,}800/(1+0.08)^{10}$	125,433
Total (10 year) NPV		1,817,090

Since NPV > 0, then the transfer and diffusion of the solar home systems technology is profitable with the selected combination of measures.

1.3 Barrier Analysis and Possible Enabling Measures for Solar Dryer

1.3.1 General Description of Technology: Solar Dryers

Direct solar drying has traditionally been used for processing and preserving food, vegetable, fruits crops and other products by laying products out in the sun to dry.

In many countries of the world, the use of solar thermal systems in the agricultural area to conserve vegetables, fruits, coffee, tea and other crops has shown to be practical, economical and the responsible approach environmentally. Solar heating systems to dry foods and other crops can improve the quality of the product, while reducing waste produce and use of traditional fuels; thus improving the quality of life.

In Kenya the National Cereals and Produce Board is responsible for drying cereals especially wheat, maize and beans and other legumes. The main source of energy used is diesel.

In the Tea Estates of Kericho, one company has installed machines that use solar energy to wither the tea leaves as part of the processing. This has cut costs of electricity earlier used by about fifty per cent.

There are different categories of Solar Dyer Systems according to the intended use of each type of system. Individual family units are those systems designed to dehydrate small quantities of units, vegetables or herbs for purpose of extending the availability of those products at the family level.

Medium scale systems are meant to meet the need of individuals and groups, cooperatives or associations to supply a greater quantity of product to reach more markets. Large scale commercial applications require greater capitalization, and are designed to dry very large quantities of product for village cooperatives as well as large commercial farming operations.

Kenya being dominantly an agricultural country, the use of Solar Dryers would greatly increase the contribution of agriculture to food security and increase in export of the products. It should be further noted that:

- Solar food drying is a skill that if well promoted can easily be assimilated into most cultures
- Solar Dryers are a cost – effective solution to food preservations in sunny climates in countries applying the technology.

- The use of solar dryer systems to conserve vegetables, fruits, coffee, tea and other cops is practical, economical and environmentally friendly
- Solar dryer systems improve the quality of the product, while reducing waste produce and traditional fuels.
- Use of solar drying systems will result in significant savings to farmers and open new markets as mentioned earlier in Kericho Tea Estate
- Solar dried products reduce storage and transportation costs
- The technology now in existence can be adapted in Kenya to meet almost every agricultural need
- Currently there is lack of sufficient information in the country to publicize the technology as more farmers are only familiar and apply open air sun drying.

Characteristics

The Solar Dryers technology entails conversion of light to heat which then is trapped and absorbs moisture from the product making it dry. This prevents especially food from decay and spoilage.

There are two broad groups of Solar-energy dryers, namely passive or natural – circulation solar energy dryers and active or forced-convection solar dryers (hybrid solar dryers). Solar dryer designs can be differentiated according to their operating temperature ranges, heating sources and heating modes, operational modes or structural modes. Through properly designed forced convention (active) solar dryers are agreed generally to be more effective and more controllable than the natural-circulation (passive) types.

There are different categories of Solar Dryer Systems according to the intended use of each type of system. There are some easy-to-fabricate and easy to operate dryers that can be suitably employed at small-scale factories. Such low-cost drying technologies can be readily introduced in rural areas to reduce spoilage, improve product quality and overall processing hygiene. These individual family units are designed to dehydrate small quantities of units, vegetables or herbs for purpose of extending the availability of those products at the family level.

Medium Scale systems are meant to meet the need of individuals and groups, cooperatives or associations to supply greater quality of products to reach more markets. Large scale commercial Applications require greater capitalization and are designed to dry very large quantise of products for village cooperatives as well as large commercial farming operations.

Economic Benefits

- Running cost are low compared to fossil fuel and electricity
- Savings made in fossil fuels and electricity which are the main source of all cereals dryers in the country
- Poverty reduction
- Employment creation and earnings to the community
- Foreign exchange savings
- Increased incomes to the farmers
- Reduced volume for transport
- Savings to farmers
- Improved food security

Environmental Benefits

- Quality and hygiene ensured as opposed to drying cereals on tarmac roads
- Reduced GHG emission

- No air-pollution hence good health

If solar dryers replace the use of fuel wood, fossil fuel and thermal electricity, there would result in reduced GHG emissions.

Social Benefits

- Improved health conditions of the workers and farmers
- Improve nutritional conditions

1.3.2 Identification of Barriers for Solar Dryers Technology

The process of barrier identification was based on consultants' own knowledge and stakeholder consultation. These included among others:

- A desk study and literature review
- Stakeholder workshops and individual consultations
- Guidance from the TNA Guidebook
- Market mapping tool

i) Market Chain Actors and Links

There are several actors who take part in the linkage between the consumers, the suppliers at retail and wholesale levels, the importers, producers and manufacturers.

The market chain involves individual consumers, institutions, organizations and private companies. In market mapping the role of Government to provide an Enabling Environment is very important as well as service providers that include the NGOs and groups that are involved in training, capacity building and awareness promotion as shown in the diagram below:

Table 1.5: Gross List of Barriers and their Categories

Barrier Listing	Category
1. Cost of the systems (upfront cost)	Economic and financial
2. Inadequate skilled manpower	Human skills
3. Lack of quality control and warranties	Technical
4. Lack of maintenance and after sales services	Technical
5. Lack of technical infrastructure	Technical
6. Inadequate awareness	Information and awareness
7. Lack of institutional and regulatory framework	Institutional capacity
8. Assurance of durability	Technical
9. Misuse of facility	Human skills
10. Availability of Solar Energy	Weather conditions
11. Lack of Investor Confidence	Economic and Financial
12. Insufficient Legal and Policy Framework	Policy and legal

ii) Screening Barriers

After screening of barriers, major barriers were identified as follows:

- Cost of the systems (upfront cost)
- High interest rates
- Inadequate high manpower
- Inadequate awareness
- Inadequate policy, legal and regulatory
- Inadequate physical and technical infrastructure

1.3.2.1 Economic and Financial Barriers

i) Cost of the Systems (High Up-front Cost).

This is the central barrier to transfer and diffusion of solar dryers technology. The costs of the different categories of the Solar Dryers range from $50 to $1,500. This amount may not be readily available to the ordinary farmer in the rural area. The farmer in the rural area has limited access to financial institutions and to credits.

ii) High Interest Rates

Local banks charge between 15% and 30% interest rates for those who take loans. Borrowers need collateral before they can get loans. The interest rates are a disincentive to those willing to borrow money from banks to buy solar dryers since they cannot afford loan repayments.

1.3.2.2 Non Financial Barriers

i) Inadequate Skilled personnel

There are no skilled personnel to install and operate the technology. The farmers are largely not familiar with the technology and cannot therefore readily use it.

ii) Inadequate Awareness

Generally there is an absence of good information about solar dryer technology despite the fact that solar food processing is most needed in the country. The farmers do not have information on the product, benefits, costs, financing sources and market potential. The civil societies should be encouraged to popularize this technology.

iii) Inadequate Policy, Legal and Regulatory Framework

The Government has not shown commitment in promoting Solar Dryers by formulating the necessary policies and legislations especially in the Agricultural Sector with a view to ensure food security.

Table 1.6: Decomposition of the Starter Barrier

Broad Category	Barrier within Barrier	Elements of Barrier	Dimension of Barrier
Economic and Financial	High Up-front cost	Inaccessibility to capital High Interest rate Import duty	Farmers financial inability Lack of incentive Demoralised farmers
Non-economic and financial	Inadequate skilled man-power	Poor operation and maintenance	Misuse of solar dryers

For details on barrier analysis with assistance of logical problem analysis tool, please see problem tree (Annex IIB).

1.3.3 Process of Identifying Measures

The following process was used to identify measures for solar dryers technology
i) A desk study of policy papers and other pertinent documents
ii) Workshop by technology working groups and which included a brainstorming session. This workshop was held on 25th July 2012 at Laico Hotel, Nairobi (See Annex IV)
iii) Expert and stakeholder consultation (one on one basis)
iv) Market mapping tool-consumer goods and capital goods. The elements in the market environment and the relation to the market chain were used to identify barriers for SHS.

To address the issue of Viable Solar Dryer System the following measures will be undertaken:

1.3.3.1 Economic and Financial Measures

i) This measure will be implemented by ensuring access to financial institutions, access to credit for consumers, low interest rates, low tax on profits, low cost of material and labour, low discount rates, increased incentives, provided by an enabling environment by the Government, and encourage public private sector partnership.
ii) The government is in the process of starting a Green Energy Fund Facility to be accessed at concessionary rates to people wishing to invest in green energy technologies.
iii) Setting up of local assembling Industries for solar dryer components and enhancing R& D for the technology.
iv) Remove VAT on solar dryer.
v) Establishment of focused training programme for solar dryer technicians
vi) Lend funds to viable renewable energy projects on concessional rates under the future Green Energy Fund Facility
vii) Setting up of local assembling industries for solar dryer parts and components and enhancing R& D for solar dryer technology.

1.3.3.2 Non Financial Measures

i) Policy legal and regulatory measures
The Government to provide an enabling environment by formulating policies and laws that encourage and promote the technology. This should be strengthened by ensuring enforcement of the policies and laws.
ii) Trained Personnel
Development of human skills is vital for ensuring that there are trained experts to manage the technology. There has to be in place skilled personnel for the technology. The farmers have equally to be trained in the use of the technology.
iii) Information and Awareness
Potential uses of this technology have to be provided with relevant information on the product, benefits, costs, financing sources and market potential. The media have to be motivated to develop interest in rooting the technology.
iv) Conduct adequate information and awareness campaigns through print and electronic media
v) Initiate research and development activities for solar dryer technology through public and private sector partnership.
vi) Strengthen regulatory framework for solar dryer technology.
vii) Establish critical mass of locally trained personnel
viii) Formulate enabling Policy, Legal and regulatory framework for solar dryer technology

1.3.4 Cost Benefit Analysis (CBA) for Solar Dryers Technology

The Net Present Value (NPV) was calculated by determining the Net Value by estimating the Cost of Benefits of new technology vis-à-vis the Cost of the old technology.

$$NPV = \sum \text{Net Benefit}$$

$$\overline{\quad (1+i)^t \quad}$$

Net Benefit= Benefit – Costs
t = year
(i) = Discount rate = 0.05 (5%)
Total benefits =$ 3000
Total Costs = $ 2500
Net Benefit = 3000 – 2500 = 500N

$$NPV = \frac{500}{1 + 0.05} = \frac{500}{1.05} = 476$$

Since the NPV is greater than zero, the Solar Dryers technology is therefore profitable.

Similar calculations were done for the next nine years and the results are presented in table 1.7 below

Table 1.7: NPV for Solar Dryers

Year	Calculation	PV (US$)
1	$500/(1+0.05)^1$	476
2	$500/(1+0.05)^2$	454
3	$500/(1+0.05)^3$	432
4	$500/(1+0.05)^4$	411
5	$500/(1+0.05)^5$	392
6	$500/(1+0.05)^6$	373
7	$500/(1+0.05)^7$	355
8	$500/(1+0.05)^8$	338
9	$500/(1+0.05)^9$	322
10	$500/(1+0.05)^{10}$	307
Total (10 year) NPV		**3,861**

1.4 Linkages of the Barriers Identified in SHS and Solar dryer Technologies

The linkages of different barriers faced by SHS and Solar dryer technologies in the energy sector were analysed. Table 1.8 below shows linkages between Solar Home Systems and Solar dryer technologies.

Table 1.8: Barriers linkages between SHS and Solar dryer technologies

Category	Solar Home Systems/ Solar Dryer
Economic and Financial barriers	The initial cost may not be affordable to the rural folk
Inadequate Information and Awareness	Rural populations have little or no information on the technologies.
Technical Barriers	Lack of technical capacity by the farmers.
R & D	Both the Government and the Private Sector have not invested in Research and Development
Institutional barriers	Lack of coordination between the Government agencies and farmers.
Policy Legal Regulatory	Lack of supportive Policy Legal Instrument
Market Failures	Few manufacturers and Small market demand

1.5 Enabling Framework for Overcoming the Barriers in Sector A: The Energy sector

1.5.1 Identifying Common Support Measures for SHS and Solar Dryers

The purpose of charting the enabling environment is to understand the elements that affect the market chain for solar PV and thus make it possible to examine the powers and interests that drive change.

The existing enabling framework for SHS and solar dryer technologies is shown at the top of Annex IA and IB for technology A1 and technology A2 respectively. These include corruption control; import and VAT exemptions; finance policy, corruption control and subsidy on interest rates. Common supporting services are shown at the bottom of Annex IA for technology A1 and Annex IB for technology A2 respectively and include the following: information and awareness campaign, financial services, Research and Development, market information and test stations for quality control.

The following are the common measures for both solar home systems and solar dryer technologies

i) The Energy Policy and the Energy Act. There is need to review both the Energy Policy and Act with a view to promoting development and diffusion of the SHS and solar dryer technologies
ii) Corruption control. There is need to enforce laws on corruption
iii) Solar technology standards. There is need for the Kenya Bureau of Standards to enforce national standards for SHS and solar dryer technologies
iv) Capacity building. There is need to strengthen capacity building for SHS and solar dryer technologies
v) Green Fund Facility. The Green Energy Fund will be a financial mechanism to support development and diffusion of SHS and solar dryer technologies in the country.

Table 1.9 (a): Technology Specific Measures-SHS

Measure Category	Solar Home Systems
Economic and Financial High Initial Investment	 Setting up of local assembling Industries for PV and SHS parts and components and enhancing R& D for solar PV and SHS technologies
High cost of solar panels and batteries	Setting up of local assembling industries for solar panels and batteries.
Lack of subsidies on SHS components	Remove VAT on solar batteries and other SHS components. Currently VAT exemptions applies to complete SHS package as opposed to single component
High cost of installation	Establishment of focused training programme for solar PV and SHS technicians
High Interest rates	Land funds to viable renewable energy projects on concessional rates under the future Green Energy Fund Facility
Non –Economic and Non-Financial Measures Inadequate Information and awareness Lack of Research and development Weak regulatory framework	 Conduct adequate information and awareness campaigns through print and electronic media Initiate research and development activities SHS through public and private sector partnership Strengthen regulatory framework

Table 1.9 (b): Technology Specific Measures- Solar Dryers

Measure Category	Solar Dryers
Economic and Financial High up- front cost	Setting up of local assembling industries for solar dryer parts and components and enhancing R& D for Solar Dryer
High interest rates	Land funds to viable renewable energy projects on concessional rates under the future Green Energy Fund facility
Non-Economic and Non-Financial Measures Inadequate information and awareness	Conduct adequate information and awareness campaigns through print and electronic media
Inadequate skilled personnel	Establish critical mass of locally trained personnel
Inadequate policy, legal and Regulatory framework	Formulate enabling Policy, Legal and regulatory framework for solar dryer technology

2. WASTE MANAGEMENT SECTOR

During the stakeholders meeting the information from the private sector was that the waste paper and plastic recycling technologies are adequately deployed in Kenya. In fact the main barrier to its wider diffusion at present is that the quantities of the waste papers and plastics do not meet the demand.

For this reason justification of the technology was abandoned. Waste composting is a well-known and widely used by farmers. Therefore only methane capture technology was identified as having high potential for diffusion if barriers were adequately addressed.

Methane capture from household bio-digesters was the most preferred technology because it has many benefits especially for rural communities in addition to global benefits. The main ones being:

- Clean indoor environment and hence improved health
- Contribution to conservation of forests
- Accessibility of livestock wastes
- It is owned by the individual household
- It provides enriched residues for crops which the farmer could use to increase crop production instead of commercial fertilizers which have become very expensive.
- It has great potential for Income generation leading to poverty reduction within rural communities

2.1 Preliminary Targets

The preliminary targets for Methane Capture technology are farmers who undertake mixed farming, institutions and commercial enterprises.

About 120,000 households, institutions and commercial enterprises are targeted for diffusion of the technology up to Kenya's development Vision Year 2030. With 5 persons per household a total of 600,000 persons will have access to the technology. The expected demand will attract about 200 construction companies distributed across the country and about 1000 maintenance technicians and 100 suppliers of components.

2.2 Barrier Analysis and Possible Enabling Framework for Methane Capture Technology from Bio-digesters

2.2.1 General Description of Technology

Methane Capture Technology

Methane Capture technology involves excavating the ground and constructing bio-digestion tank using the usual construction materials such as stones and cement. The tank is sealed to ensure anaerobic decomposition of bio-degradable materials.

The tank has an inlet through which bio-degradable raw materials are injected to the bottom. Above the raw materials layer a chamber provided into which the generated methane gas is emitted and stored. An outlet is provided within the bio-degradable materials layer through which the residue slurry is exhausted to the open space outside.

At the top of the methane storage chamber a metal pipe is connected through which the methane gas flows to the gas burner, the lantern or any other point of use which is either a cooking burners or lanterns for lighting. The biogas can also be pumped into cylinders for storage or sale to users.

Two types of technology have been applied in Kenya for household biodigesters namely: Rotating drum: The metal lid which encloses the gas chamber is made such that it is manoeuvrable so that the gas contained therein is redistributed and 2 the fixed dome where the chamber container lid is fixed. This technology is currently being applied in

the country. The digesters can be constructed in different sizes depending on the requirements of the household and its capacity to supply raw waste materials.
Currently the bio- digesters are being constructed in sizes of $6m^3$, $8m^3$, $10m^3$, $12m^3$. The bio- digesters generate different amounts of bio- gas according to sizes.

The main aim of methane capture technology is to prevent methane gas from escaping to the atmosphere where as a greenhouse gas its global warming potential is 21 times more powerful than Carbon Dioxide.

Status of Technology in Kenya
Biogas technology was introduced in Kenya about 50 years ago. Since that time, the technology has been promoted by Government Ministries, International Institutions and Non- Governmental Organisations (NGOs).

However diffusion in the country has been hampered by financial and technical barriers such as high cost of construction, inadequate financial support, low design, construction and management skills, social and cultural beliefs and inadequate information.

The German GTZ in collaboration with the Ministry of Energy has been promoting the technology in the country for about 20 years now.

Since 2009, the Netherlands Government has provided funding for implementation of a biogas project known as Kenya Domestic Biogas Programme (KEDBIP). The projects objective is to construct about 12,000 bio- digesters of different sizes.

The technology deployment has focused mainly on the high potential areas of the country where it has had great impacts as energy sources environmental conservation and improvement of crop production.

Characteristics
Methane capture technology is consumer oriented. Its market characteristics include

- A large number of potential customers in both rural and urban areas
- High initial capital cost
- Low maintenance cost
- Requires continuous supply or raw materials
- Low or zero cost of raw materials
- It does not require high technical skills
- Its acceptability and diffusion requires high marketing promotion including demonstration for awareness and technical capacity building especially with regard to operation by users.

Benefits of energy generation through methane capture from bio- digesters

- Employment creation through construction and maintenance of equipment
- Improved health since methane combustion emits less air pollutants than bio mass
- Less use of kerosene in rural areas
- Less use of bio mass fuels leading to forest conservation.
- It contributes to abatement of greenhouse gases.
- Energy use efficiency especially in rural areas.
- The waste residues are comparable to mineral fertilizers in plant nutrients and can therefore be used in farms for crop growth resulting in great savings for the farmers who use them instead of expensive commercial fertilizers
- It has potential for commercialization

2.2.2 Barrier Identification for Methane Capture

Barrier identification was based on:

- Desk study of national development plans and legislations.
- Current status of the technology in the country.
- Discussions with sample households and farmers.
- Workshop by technology working groups.

- UNDP, UNFCCC Hand Book on technology needs Assessment for Climate Change
- Market mapping.

Market Chain Actors and Links
Methane Capture bio-digesters are constructed at the households or institutions where the gas is used for cooking and lighting. The market demand is from farmers in rural areas and is driven by factors such as availability of farm wastes and the need for affordable clean energy. Some institutions within the country are conducting training of households on the operation of bio-digesters through demonstrations among other methods. Public awareness seems to be a major barrier to diffusion of the technology. The other barrier is the availability of skilled technical personnel for construction of the bio-digesters.

Because of the high costs of construction and components many households find the bio digesters to be of low priority. The market chain is therefore not developed to a level where significant impact can be seen.

Barriers to the technology deployment and diffusion were subjected to analysis during a meeting with stakeholders.

The following barriers were identified by stakeholders and were consequently categorized into economic/financial and non- economic barriers:

2.2.2.1 Economic and financial barriers

- **High cost of construction of bio-digesters.**
  Although most of the construction materials are local they are expensive. The construction technicians also demand high labour costs because they are few. Imported components are charged high import duty.
- **High transaction costs.**
  Feasibility studies are expensive because there are only a few experts.
- **High interest rates charged by financial institutions.**
  Financial institutions in the country charge high interest rates for loans. Most small scale farmers are unable to afford the loan repayments.
- **Lack of financial incentives.**
  The Government does not have in place financial incentives that could encourage small scale farmers to acquire bio-digesters at affordable costs.
- **High maintenance costs.**
  Replacement parts of bio-digesters are expensive. The technical personnel charge high fees because they are few.

2.2.2.2 Non-financial barriers

- **Lack of skilled technical personnel for construction and maintenance**
  Well trained technicians are few and are not able to meet demand. The bio-digesters therefore remain un maintained for long periods
- **Low awareness of the benefits of bio-digesters as sources of reliable and clean energy**
  Most of the small scale farmers are not informed of the benefits of bio-digesters in terms of health, farm inputs and clean energy.
- **Lack of training of potential bio-digester users**
  Most of the potential users do not know how to operate bio-digesters for proper generation of methane gas energy.
- **Lack of adequate space for construction of large bio-digesters.**

Many of the small scale farmers have small areas of land which they utilise for mixed farming. The space may not be able to accommodate large bio-digesters.

- **Lack of market links**
  Market links among the farmers, themselves and between the farmers and construction companies are low and therefore the market is low.

Table 2.1 Methane Capture from household bio- digesters
Barrier Identification

1. Economic and Financial Barrier	**Barrier category**
a) High cost of capital	
• Scarcity of cheap capital	Economic and Financial
• Government policies on capital (taxation)	Economic and Financial
b) Financially not viable	
• High cost of construction	Economic and Financial
c) High transaction cost	
• Feasibility studies	Economic and Financial
• Bureaucracy	Institutional Failure
• Inaccurate cost-estimation	Technical Skills
d) Inappropriate financial incentives	
• High import duty	Economic and Financial
• Lack of government subsidy	Economic and Financial
e) Market failure	
• Poor market infrastructure	Market failure
2. Policy, Legal and Regulatory	
a) Insufficient legal and regulatory framework	
• Complex procedures	Institutional Failure
• Inadequate regulations for climate change technologies	Legal Failure
b) In efficient enforcement	
• Inability to enforce laws and regulations	Institutional Failure
3. Institutional and Organizational Capacity	
a) Lack of professional institutions	
• Institutions to promote and disseminate few	Institutional Capacity
• Lack of Institutions to promote and enhance market	Institutional Capacity
b) Limited institutional capacity	
• Limited capacity in existing institutions	Institutional Capacity
• Limited capacity for R & D	Human Resources
4. Human Skills	**Barrier category**
a) Inadequate training facilities	
• Lack of expenses to train stakeholders	Economic and Financial
b) Inadequate personnel for project preparation	
• Lack of sufficient consultants	Technical Capacity
• Inadequate expenses in negotiating IPR contracts	Economic and Financial
• Lack of skilled personnel for the installation and operation of the technology	Technical Capacity
• Lack of service and maintenance specialist	Technical Capacity
5. Information and Awareness	
a) Inadequate Information	
• Limited dissemination of information to technology users	Information and awareness
• Lack of market information	Market failure
• Lack of access to technology resource assessment data	Information and awareness

2.2.3 Identification of enabling measures

Identification of enabling measures was done through:

- Consultation with stakeholders
- Consultant's own experience.
- Review of government Energy Policy (2004) and Act (2006)

The objective of the identified measures is to make methane capture technology viable

2.2.3.1 Economic and financial measures.

i) Reduce construction costs

The government will give waiver on import duty and other taxes on all the components that will be imported for the purpose of construction and operation and maintenance of methane bio-digesters. This is consistent with the Energy policy (2004) and Act (2006).

The justification will be based on environmental and health benefits and poverty reduction among the small scale farmers.

ii) Reduce interest rates.

The financial institutions will form partnership with the government to provide low interest loans for development of bio-digesters in order to promote clean energy in rural households towards environmental conservation.

iii) Reduce maintenance costs.

The government will give tax waiver to components that will be manufactured locally or imported for the purpose of maintenance of bio-digesters.

iv) Reduce the cost of cooking stoves and gas lamps.

The government will give tax waiver on the cooking stoves and gas lamps that use methane gas. This is in line with the energy Policy (2004) and Act (2006)

2.2.3.2 Non-financial measures

i) Make available skilled technical personnel.

Technical training institutions in the country will develop customized training courses for technicians who will undertake construction and maintenance of the bio-digesters.

ii) Bio-digesters are modified and improved to meet the emerging needs

Research and development institutions will be given funds to conduct research and development of appropriate methane capture bio-digesters that will respond to consumer demands such as those that are portable. The funding will come from a special climate fund which will be created by the government.

iii) **Implement training and public awareness campaign for users**

The responsible institutions within the government in collaboration with research centres and construction companies will conduct training and public awareness campaigns for households on the operation and maintenance of the bio-digesters.

The public awareness campaign will include explaining the benefits of methane energy production on the environment and health and also benefits to the farmers in terms of availability of organic fertilizers which are rich in plant nutrients.

iv) Establish market links for bio-gas

Market links will be developed within the households and between the households and the technology suppliers towards increasing the demand for the bio-digesters.

2.3 Cost Benefit Analysis

Household bio- digesters

During the first year it is assumed that at least 1000 households would have access to bio-digesters.

The following is the cost benefit analysis: for 1000 households

$$NPV = \frac{\text{Net benefits}}{(I + i)^{t}}$$

NPV = Net Present Value

Net benefits = Benefits – Costs

i= discount rate

t=year

i) **Benefits of Avoided Medical Costs in Kshs.**

Population: 1000 households x 5 persons = 5,000 people

1000 people get upper respiratory diseases due to indoor air pollution

Cost of travelling to the medical centre = 200

Cost of medicine = 300

Total cost of 6 trips per year: 500 x 6 = 3000

Total cost for 1000 people: 3.000,000

Cost of time lost: 400 x 1000 x 6 = 2.400,000

Total cost: 3000000 + 2.400,000 = 5.400,000

ii) **Benefits of using nutritious waste residue slurry instead of mineral fertilizers**

20 bags of Calcium Ammonium Nitrate (CAN) avoided per year

20 bags x 2000 per bag x 1000 households = 40.000000

iii) **Benefits of environmental value through conservation of forests:**

10,000 x 5,000 people = 50.000,000

iv) **Benefits of avoided kerosene**

- litres per household per week for lighting: cost of kerosene = 80 per litre
- 2 x 52 weeks x 80x 1000 = 8.320000

Total benefits

5.400000 + 40.000000 + 50.000,000 + 8.320,000

= 103.720,000

Costs to the households

i) Cost of bio- digesters construction = 60,000

ii) Cost of cooking gas stove = 2000

iii) Cost of 4 gas lanterns = 2000 x 4 lanterns = 8000

iv) Cost of pipes for water and gas 800

Total Cost per household

60,000 + 2000 + 8,000 + 800 = 70,800

Total cost for 1000 households = 70,800,000

Net benefits: 103.720,000 – 70.800,000

Net benefits in US Dollars at Kshs. 85 per Dollar

= 388,000 Dollars

Discount rate: 8% = 0.08

Net present value (NPV) = $\Sigma \frac{NetBenefit_t}{(1+i)^t}$

Year 1 PV = $\frac{388{,}000}{(1+0.08)^1}$

= US$ 462,091

Similar calculations were done for next 9 years and the results are presented in table 2.5 below.

Table 2.2: NPV for Bio-digesters
10 Year NPV

Year	**Calculation**	**NPV (US$)**
1	$388{,}000/(1+0.08)^1$	359,259
2	$388{,}000/(1+0.08)^2$	332,647
3	$388{,}000/(1+0.08)^3$	308,007
4	$388{,}000/(1+0.08)^4$	285,192
5	$388{,}000/(1+0.08)^5$	264,066
6	$388{,}000/(1+0.08)^6$	244,506
7	$388{,}000/(1+0.08)^7$	226,394
8	$388{,}000/(1+0.08)^8$	209,624
9	$388{,}000/(1+0.08)^9$	194,097
10	$388{,}000/(1+0.08)^{10}$	179,719
	Total (10 year) NPV	2,603,512

From NPV value in Table 2.5 above, it is evident that Methane Capture from Bio-digesters is highly beneficial to the communities financially and is also beneficial to the environmental conservation, and health. It is also beneficial to the farmers since it provides organic fertilizers which are rich in plant nutrients.

Methane capture technology is therefore highly beneficial to the communities financially and it also contributes greatly to environmental conservation and community health. Furthermore it contributes to global efforts to mitigate climate change by enhancing carbon sinks.

If more financial and technical assistance are made available the technology can be diffused to many more households resulting in even greater local and global benefits

2.4 Enabling Framework for Overcoming Barriers in the Waste Sector

2.4.1 Enabling Framework/Measures for Overcoming Barriers in the Waste Management Sector

The Enabling Framework measures for overcoming the barriers in methane capture technology are as given on table 2.3 below

Table 2.3: Enabling Framework/Measures in the Waste Management Sector

Barrier	Enabling Framework/Measures
High cost of capital	Reduce import duty on imported machinery and components
	Provide soft low-interest rate loans
	Provide loan guarantees
Limited Human skills	Customise training programmes in the existing training institutions
	Technology suppliers to provide training and technical manuals for construction, operations and maintenance of the systems
Lack of information and awareness on technologies	Potential investors in collaboration with government to undertake public awareness campaigns on the use of the products including print and electronic media
Lack of policy and regulatory framework on waste management and recycling	Govt to formulate waste management and recycling policy, legislation and regulations

The overall strategy for overcoming barriers in the waste management sector is shown in table 2.4 below:

Table 2.4: Overall Strategy for Overcoming Barriers in the Waste Management Sector

Barrier	Measure	Actors
High cost of capital	Reduce costs of construction materials through tax exemptions and subsidies	Government, financial institutions
Limited human skills	Increase training of technical personnel	Government, training institutions, technology developers
Lack of information and awareness on technologies	Conduct awareness campaigns including demonstrations targeted at potential investors	Government and technology suppliers
Lack of policy and regulatory framework on waste management and recycling	Formulate policy and legislation that will guide waste management in the country	Government in collaboration with stakeholders

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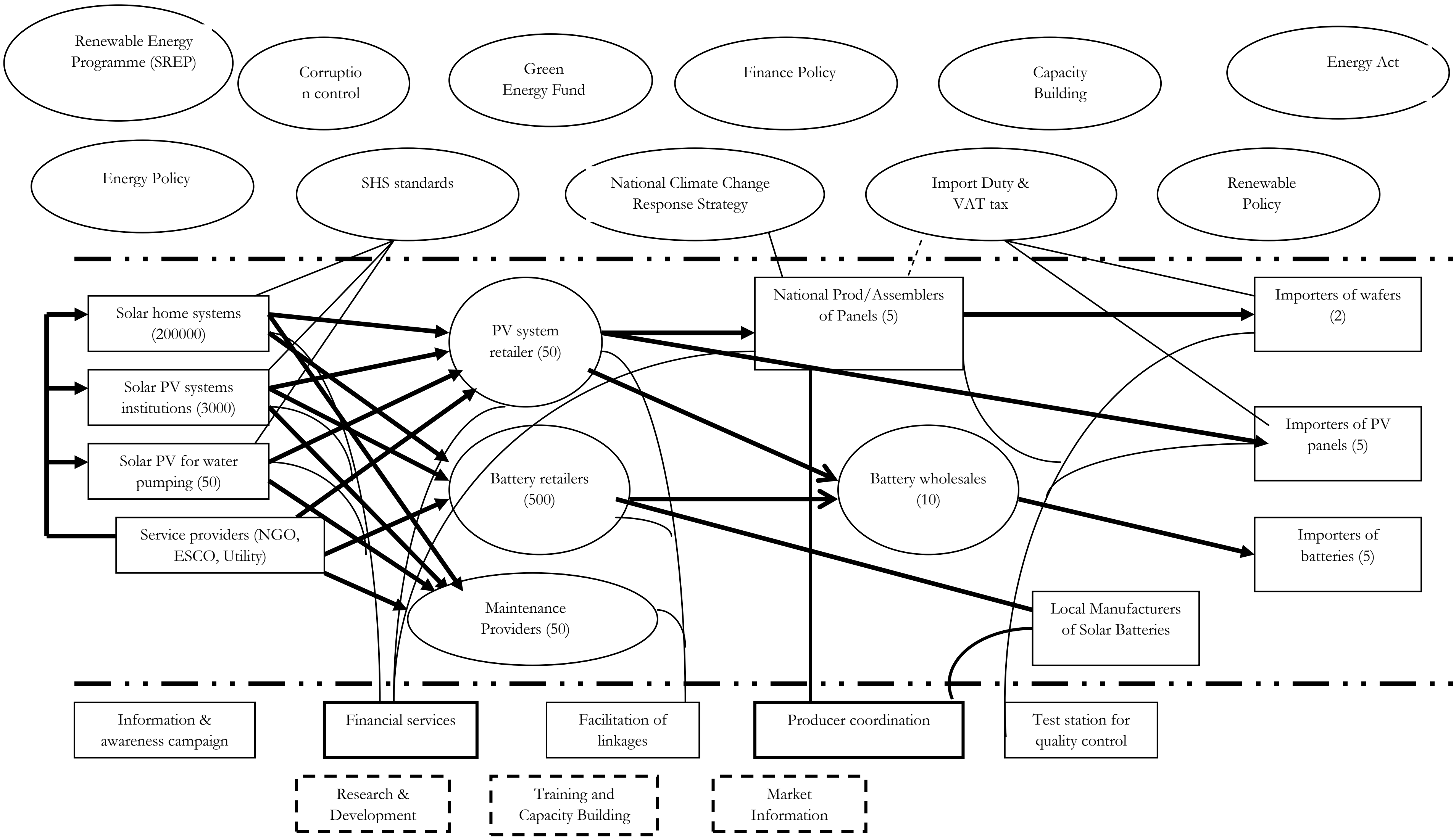
ANNEXES

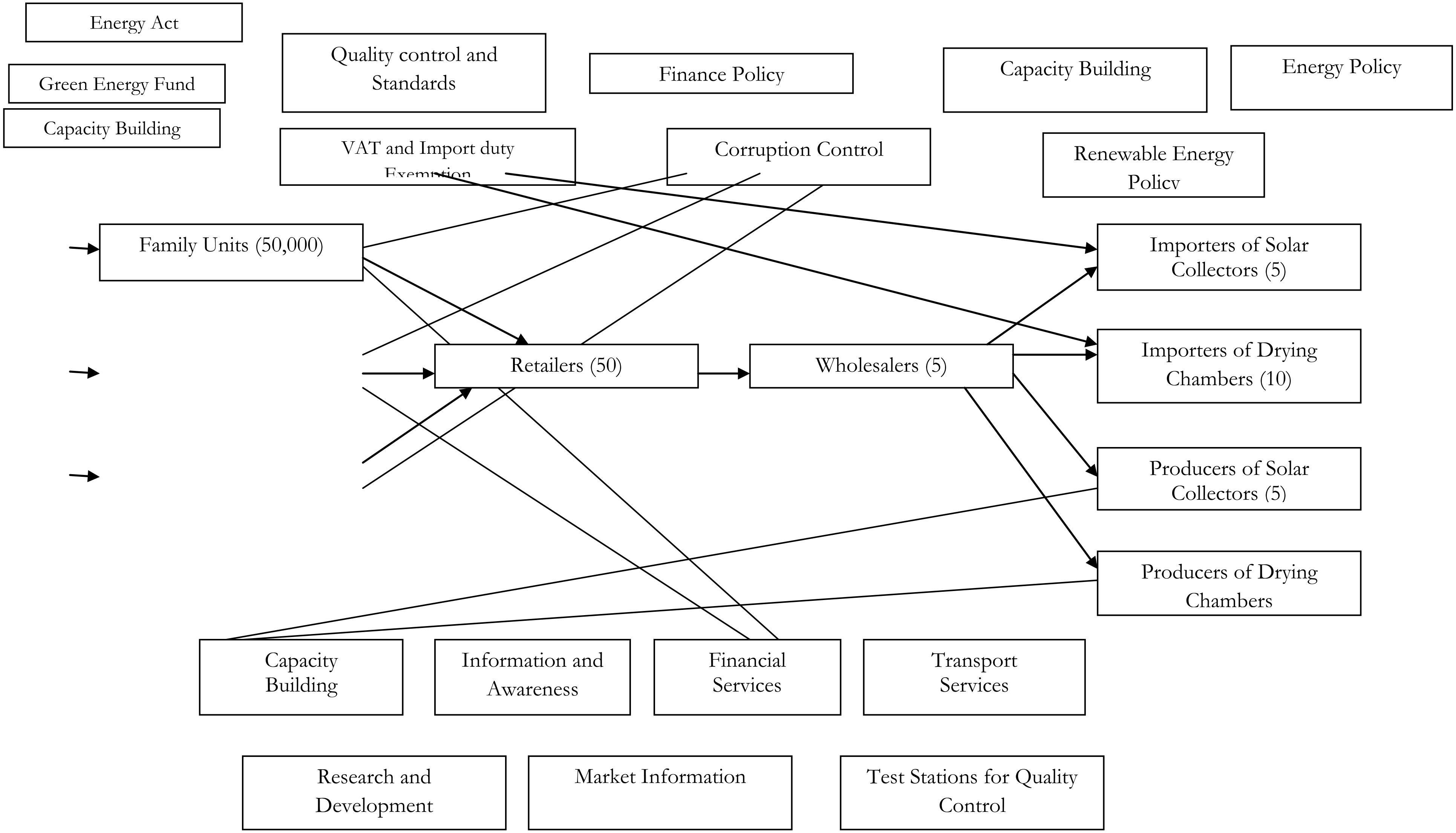
Annex IA: Market Map for the Solar PV and SHS Market Chain



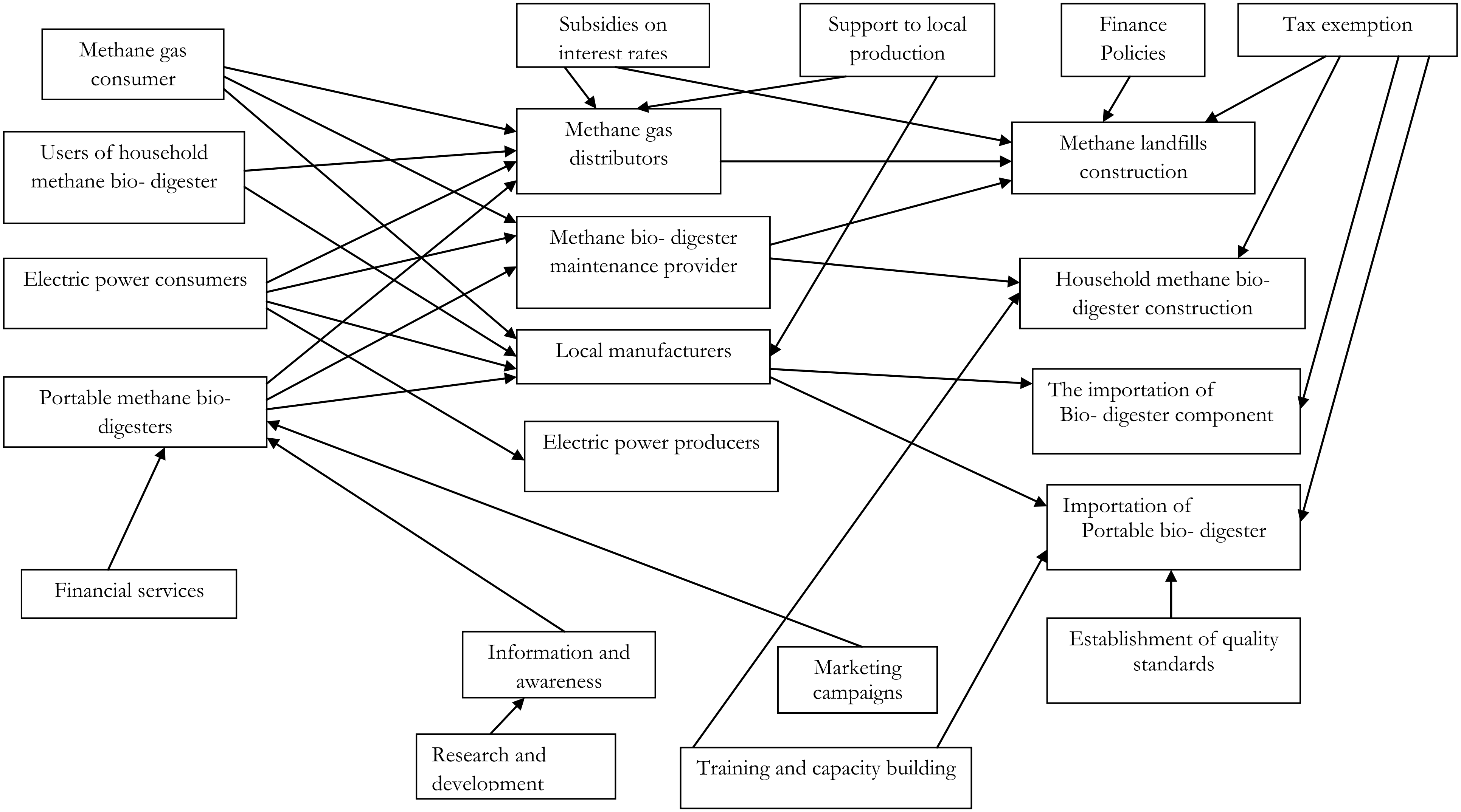
Main imports of solar PV and SHS technology parts and components include the following:

i) Solar PV modules
ii) Solar batteries
iii) Solar charge controllers
iv) Solar lighting kits
v) d.c-a.c power converters

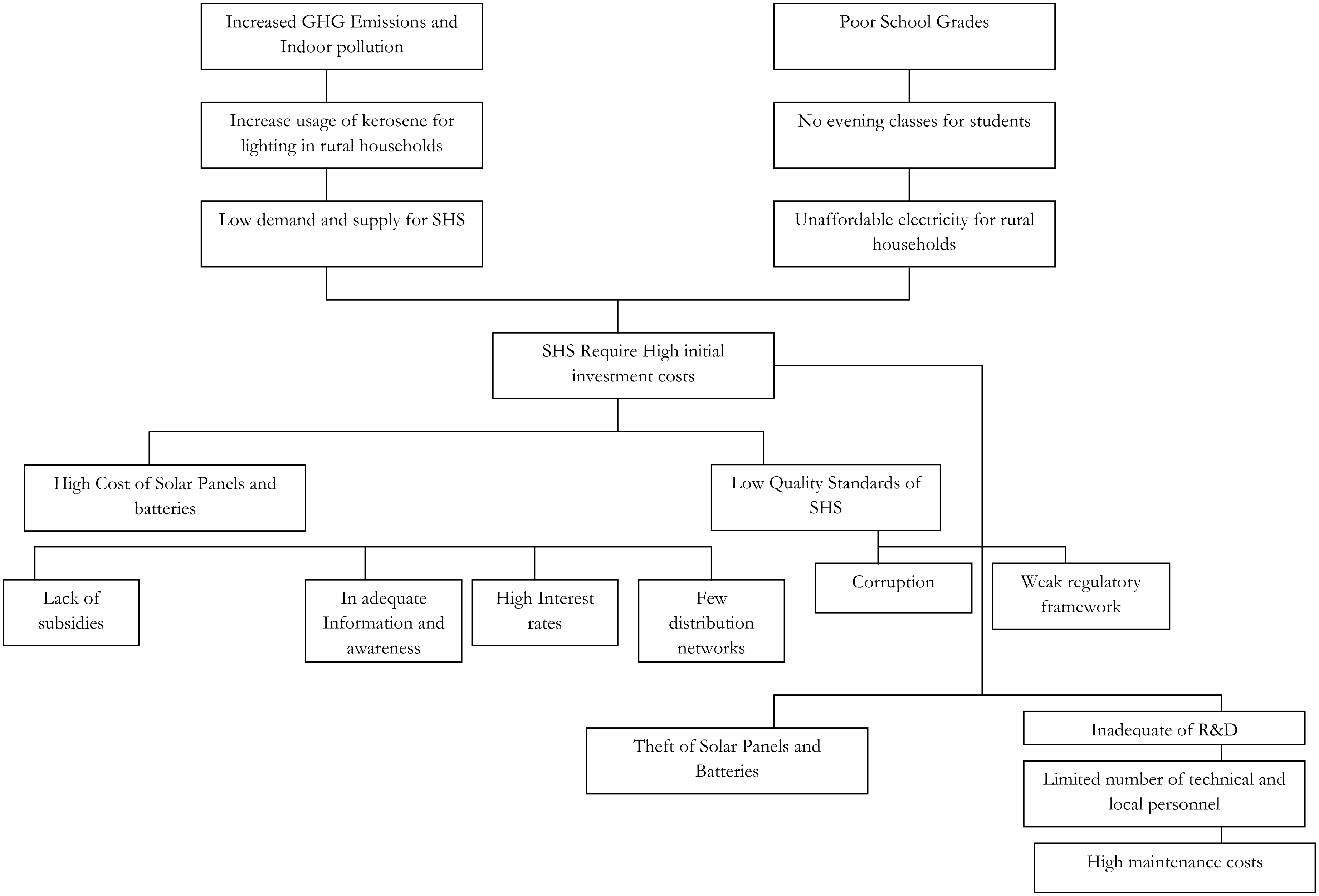
Annex IB: Market Map for the Solar Dryer Market Chain



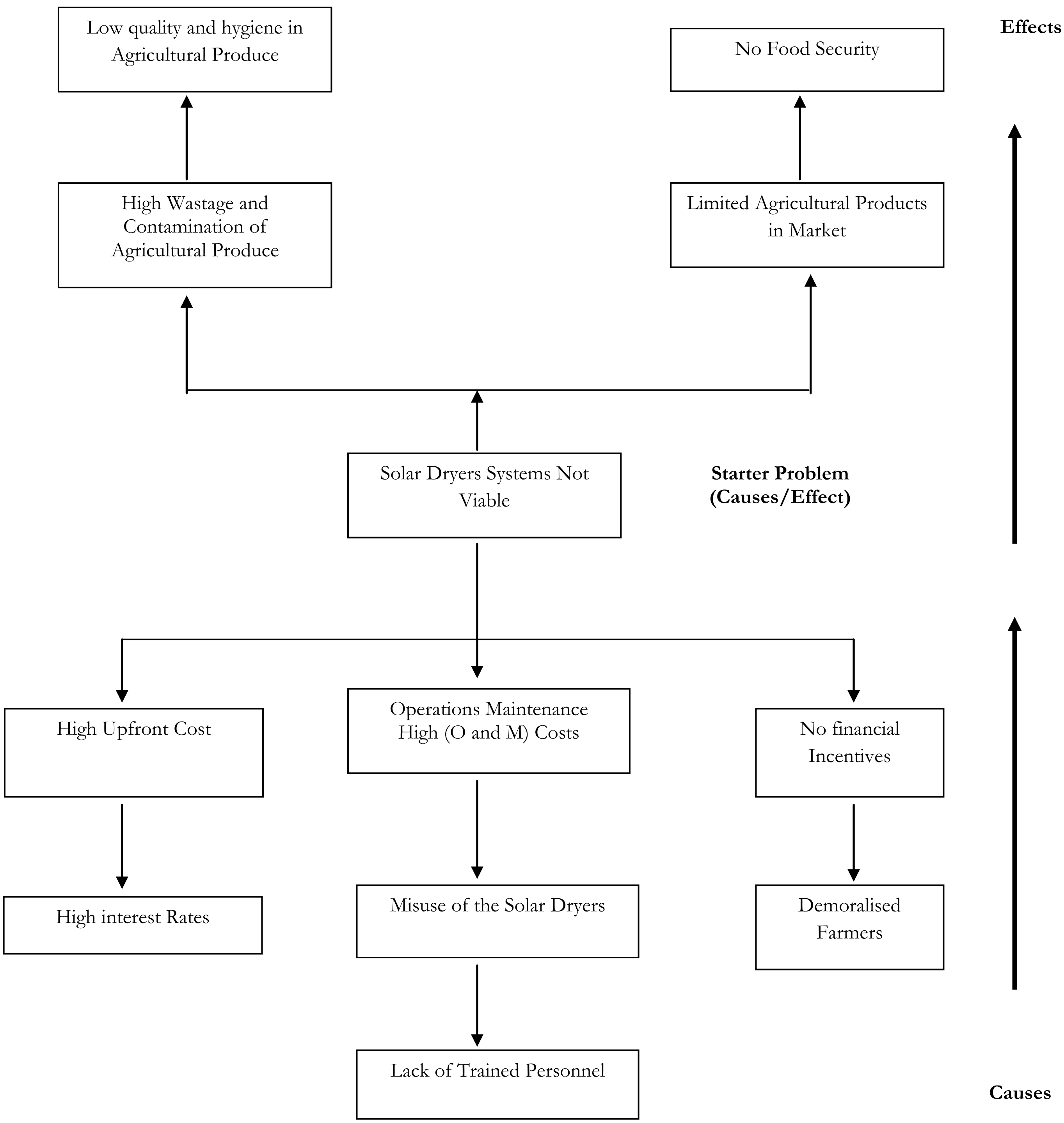
ANNEX I C: MARKET CHAIN FOR METHANE CAPTURE SYSTEM



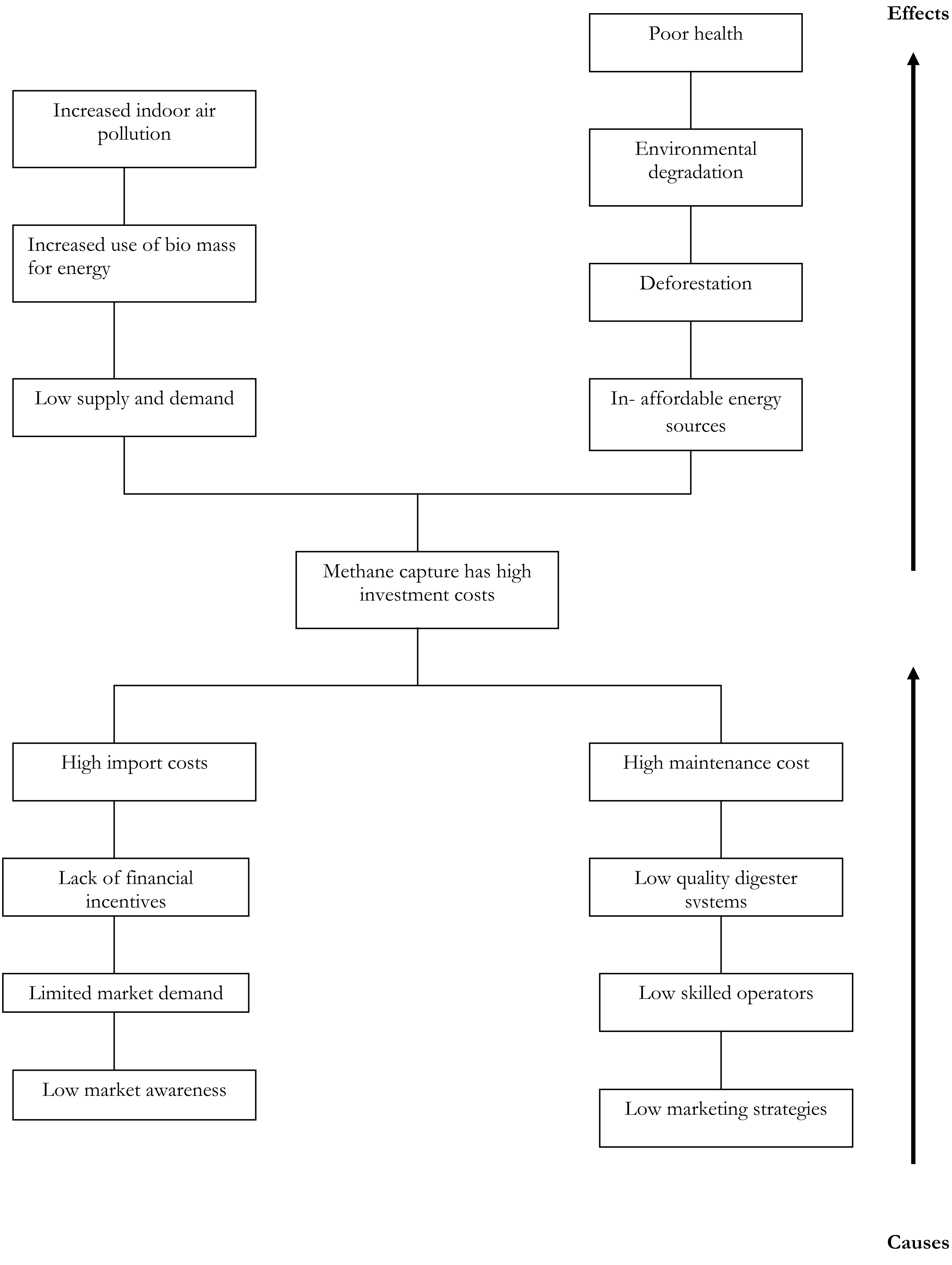
ANNEX II A: PROBLEM TREE FOR SOLAR HOME SYSTEMS



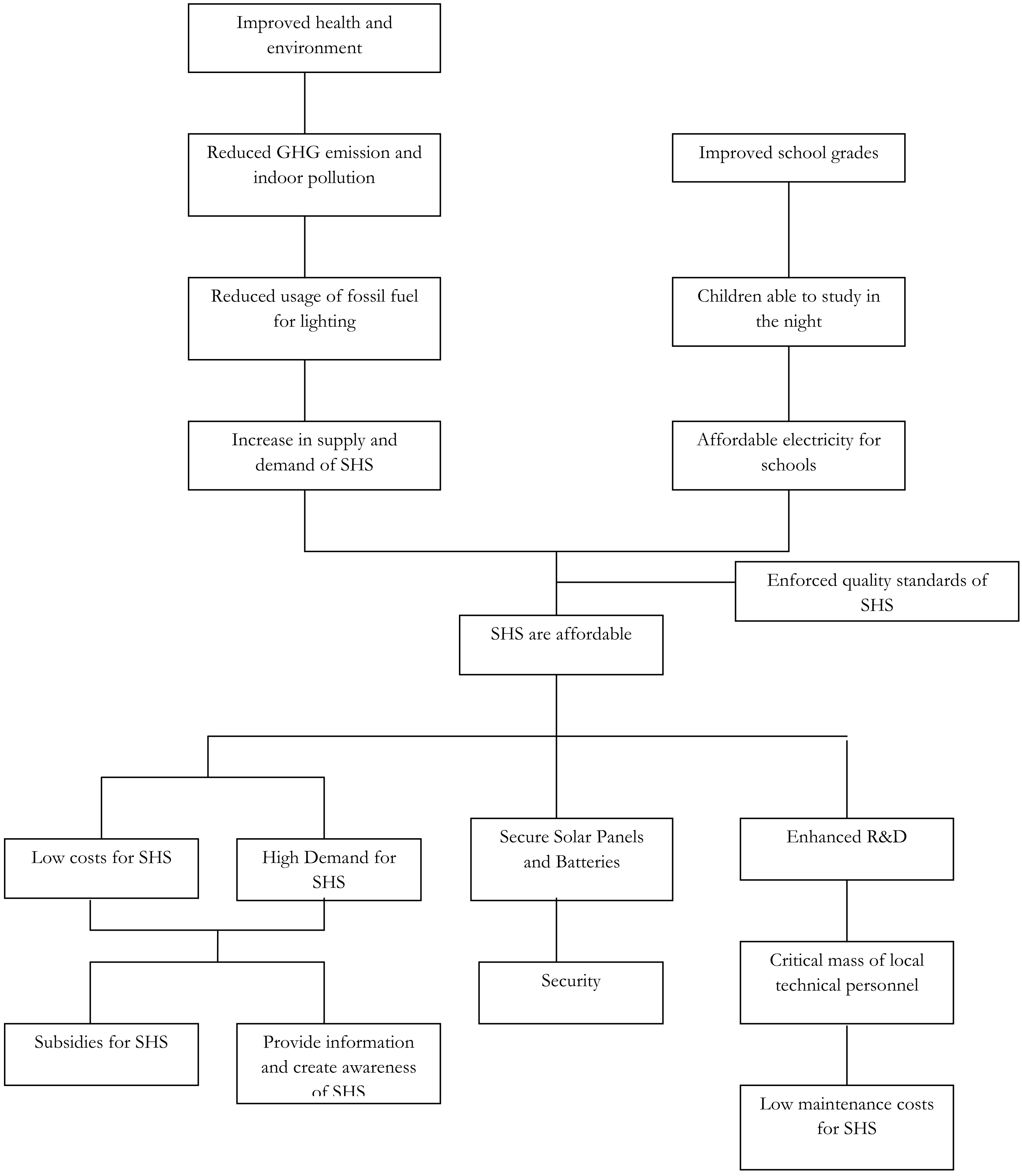
Annex IIB: Problem Tree for Solar Dryers



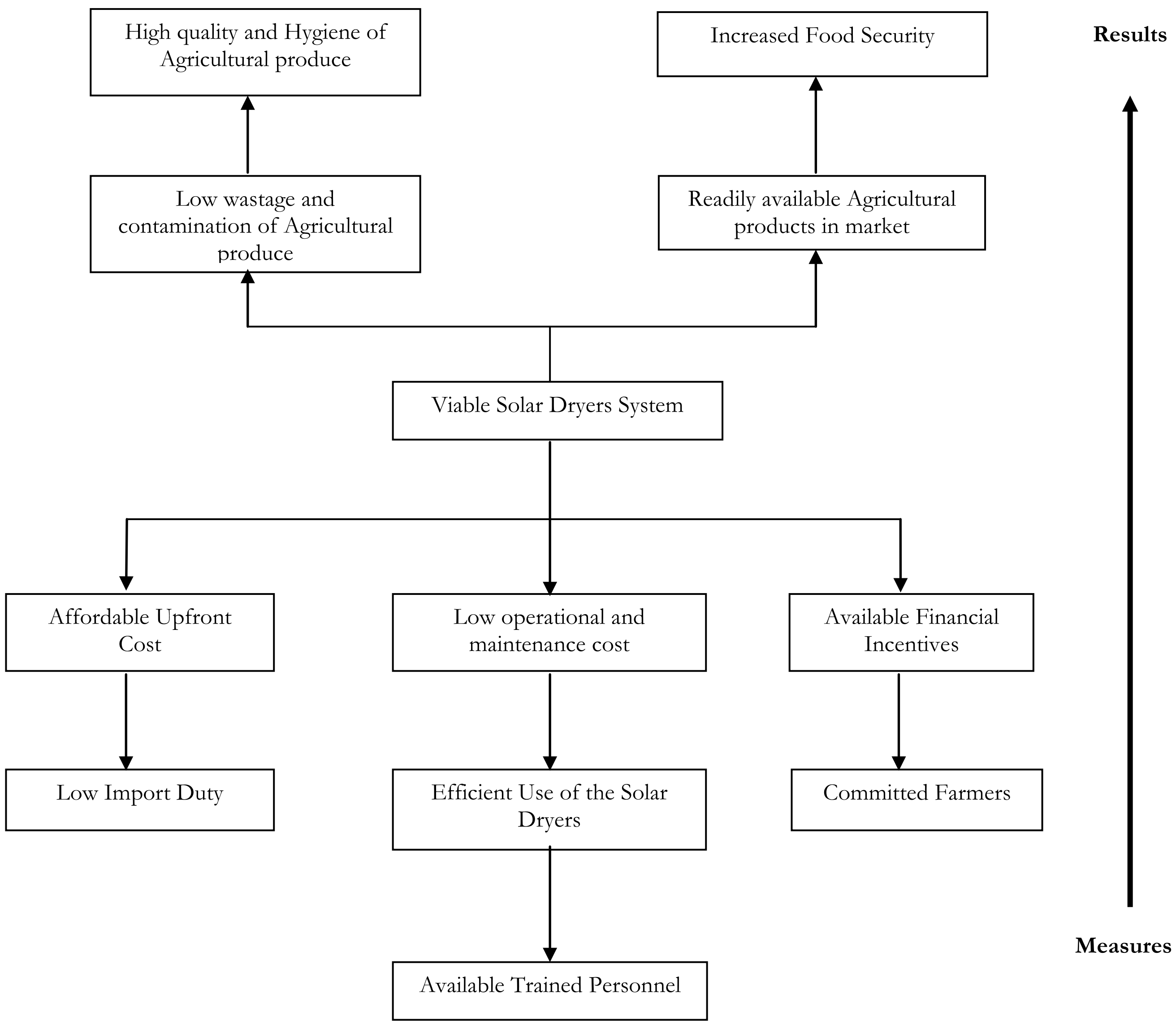
ANNEX II C: PROBLEM TREE FOR METHANE CAPTURE



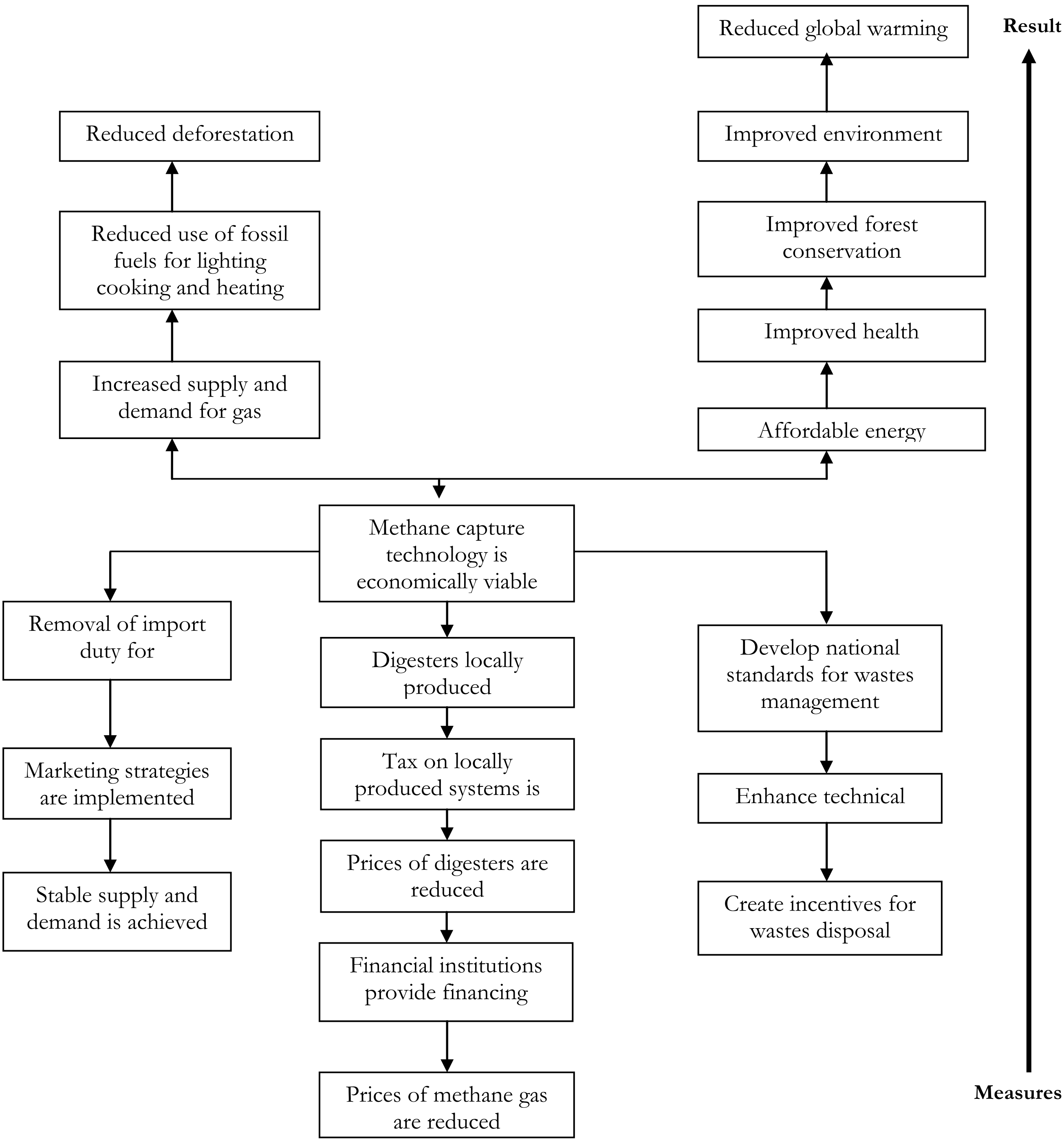
ANNEX III A: **OBJECTIVE TREE FOR SOLAR HOME SYSTEMS**



Annex IIIB: Objective Tree for Solar Dryers



Annex III C: Objective Tree for Methane Capture Systems



ANNEX IV:

THE LIST OF PARTICIPANTS WHO ATTENDED THE WORKSHOP IS APPENDED HERE BELOW

3RD TECHNOLOGY NEEDS ASSESSMENT ON CLIMATE CHANGE STAKEHOLDERS WORKSHOP ON THE WEDNESDAY 25TH JULY 2012 AT LAICO REGENCY HOTEL, NAIROBI

Attendance Sheet: 25th July, 2012

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