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Integrated Energy Farming for Rural Development and Poverty Alleviation

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INTRODUCTION

The world still continues to seek energy to satisfy its needs without giving due consideration to the consequent social, environmental, economic and security impacts. It is now clear that current approaches to energy are unsustainable. It is the responsibility of political institutions to ensure that the research and the development of technologies supporting sustainable systems be transferred to the end users. Scientists and individuals must bear the responsibility of understanding that the earth as an integrated whole and must recognise the impact of our actions on the global environment, in order to ensure sustainability and avoid disorder in the natural life cycle. Sustainability in a regional and global context requires that demands are satisfied and risks overcome, (El Bassam 2004, (Figure 1).

Current approaches to energy are unsustainable and non-renewable. Furthermore, energy is directly related to the most critical social issues which affect sustainable development: poverty, jobs, income levels, access to social services, gender disparity, population growth, agricultural production, climate change and environmental quality and economic and security issues. Without adequate attention to the critical importance of energy to all these aspects, the global social, economical and environmental goals of sustainability cannot be achieved. Indeed, the magnitude of change needed is immense, fundamental and directly related to the energy produced and consumed nationally and internationally. The key challenge to realizing these targets is to overcome the lack of commitment and to develop the political will to protect people and the natural resource base. Failure to take action will lead to continuing degradation of natural resources, increasing conflicts over scarce resources and widening gaps between rich and poor. We must act while we still have choices. Implementing sustainable energy strategies is one of the most

important levers humankind has for creating a sustainable world. More than two billion people, mostly living in rural areas, have no access to modern energy sources. Food and fodder availability is very closely related to energy availability.

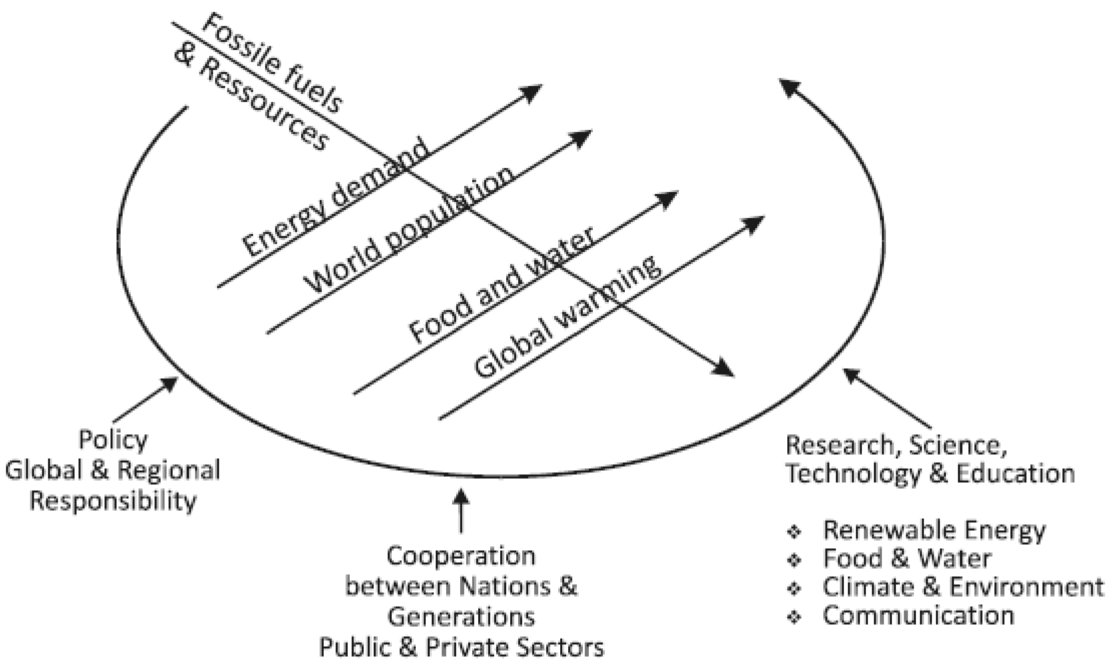

Figure 1: Sustainability in regional and global context demands, risks and measures (El Bassam
2004).

Integrated Energy Farms (IEF) for Food and Energy -
The Concept of FAO of the United Nations

In order to meet challenges, future energy policies should put more emphasis on developing the potential of energy sources, which should form the foundation of future global energy structure. In this context, the FAO of the United Nations in support of the Sustainable Rural Energy Network (SREN) has developed the concept for the optimisation, evaluation and implementation of integrated renewable farms for rural communities under different climatic and environmental conditions (El Bassam 1999).

Milestones

The IEF concept includes farms or decentralised living areas from which the daily necessities (water, food and energy) can be produced directly on-site with minimal external energy inputs. (Figure 2, 3)

Energy production and consumption at the IEF has to be environmentally friendly, sustainable and ultimately based mainly on renewable energy sources. It includes a combination of different possibilities for non-polluting energy production, such as modern wind and solar electricity production, as well as the production of energy from biomass.

It should seek to optimise energetic autonomy and an ecologically semiclosed system, while also providing socio-economic viability and giving due consideration to the newest concept of landscape and bio-diversity management.

The concept considers the following needs of the rural population to improve their living conditions and raise their living standards and to improve the environment:

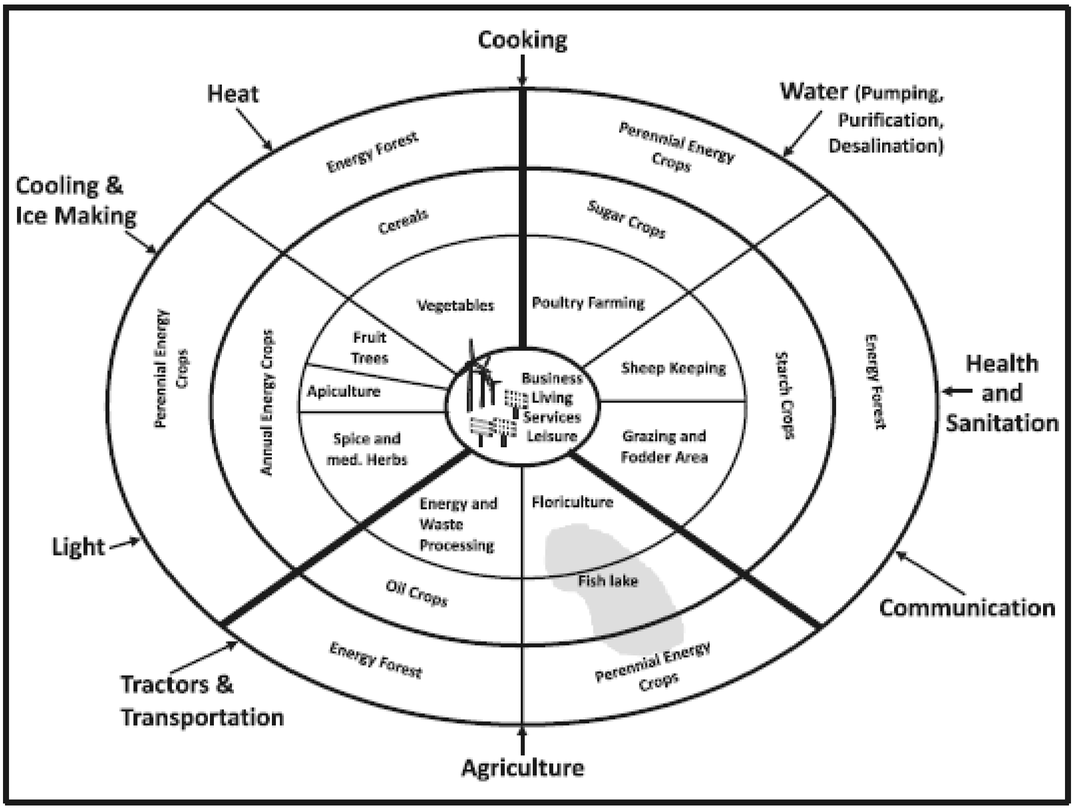

Figure 2: Basic elements and needs of integrated renewable energy community (el bassam 2001).

1 Heat

Heat can be generated from biomass or solar thermal to create both high temperature steam and low temperature heat for: space heating, domestic and industrial hot water, pool heating, desalination, cooking and crop drying.

2 Electric Power

Solar PV, Solar thermal, biomass, wind, micro-hydro

3 Water (Drinking and Irrigation)

Water is an essential resource for which there can be no substitute. Renewable energy can play a major role in supplying water in remote areas. Several systems could be adopted for this purpose:

• Solar distillation.

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• Renewable energy operated desalination units.

• Solar, wind and biomass operated water pumping and distribution systems.

4 Lighting and Cooling

In order to improve living standards and encourage the spread of education in rural areas, a supply of electricity is vital. Several systems could be adopted to generate electricity for lighting and cooling

• Solar systems (photovoltaic and solar thermal)

• Wind energy systems

• Biomass and biogas systems (engines, fuel cells, Stirling)

5 Cooking

Women in rural communities spend long hours collecting fire wood and preparing food. There are other methods which are more efficient, healthy and environmentally benign. Among them are:

- Solar cookers and ovens Biogascooking systems
- Improved biomass stoves using briquettes and pellets
- Plant oil and ethanol cookers

6 Health and Sanitation

To improve serious health problems among villagers, solar energy from photovoltaic, wind and biogas could be used to operate:

- Refrigerators for vaccine and medicine storage
- Sterilizers for clinical items
- Waste water treatment units
- Ice making

7 Communications

Communication systems are essential for rural development. The availability of these systems has a great impact on people's lives and can advance their development process more rapidly. Electricity can be generated from any renewable energy source to operate the basic communication needs such as: radio., television, weather information systems, and mobile telephone.

8 Transportation

Improved transportation in rural areas and villages has a positive effect on the economic situation as well as the social relation between the people of these areas. Several methods could be adapted for this purpose.

- Solar electric vehicles

- Ethanol, plant oil fuel, hydrogen vehicles (engines, fuel cells)
- Traction animals.

9 Food and Agriculture

In rural areas agriculture represents a major energy end use. Mechanization using renewable sources of energy can reduce the time spent in labor intensive processes, freeing time for other income producing activities. Renewable sources of energy can be applied to:

- Soil preparation and harvesting:
- Husking and milling of grain
- Crop drying and preservation
- Textile processing

The concept of an Integrated Energy Farm (IEF) or settlement includes 4 pathways (Figure 4):

1. Economic and social pathway;
2. Energy pathway;
3. Food pathway; and
4. Environmental pathway.

Basic Elements of Integration

Basic data should be collected for the verification of an IEF. Various climatic constraints, water availability, soil conditions, infrastructure, availability of skills and technology, population structure, flora and fauna, common agricultural practices and economic, educational and administrative facilities in the region should be taken into consideration. Moreover, climate also influences the production of energy-mix (consisting of biomass, wind and solar energies) essentially at a given location; and the type of technology that can be installed also depends decisively on the climatic conditions of the locality in question. For example, cultivation of biomass for power generation is not advisable in arid areas.

It is evident that throughout Europe, wind and biomass energies contribute the major share to the energy-mix, while in North Africa and the Sahara the main emphasis obviously lies with solar and wind energies. Equatorial regions offer great possibilities for solar as well as biomass energies and little share is expected from the wind source of energy in these regions. Under these assumptions, in Southern Europe, the Equatorial regions and North and Central Europe, a farm area of 4.8, 10 and 12 ha, respectively, would be needed for the cultivation of biomass for energy purposes. This would correspond to annual production of 36, 45 and 60 tonnes for the respective regions. In North Africa and Sahara regions, in addition to wind and solar energy, 14 tonnes of biomass from 1.2% of the total area would be necessary for energy provisions. Projection steps are illustrated in Figure 5.

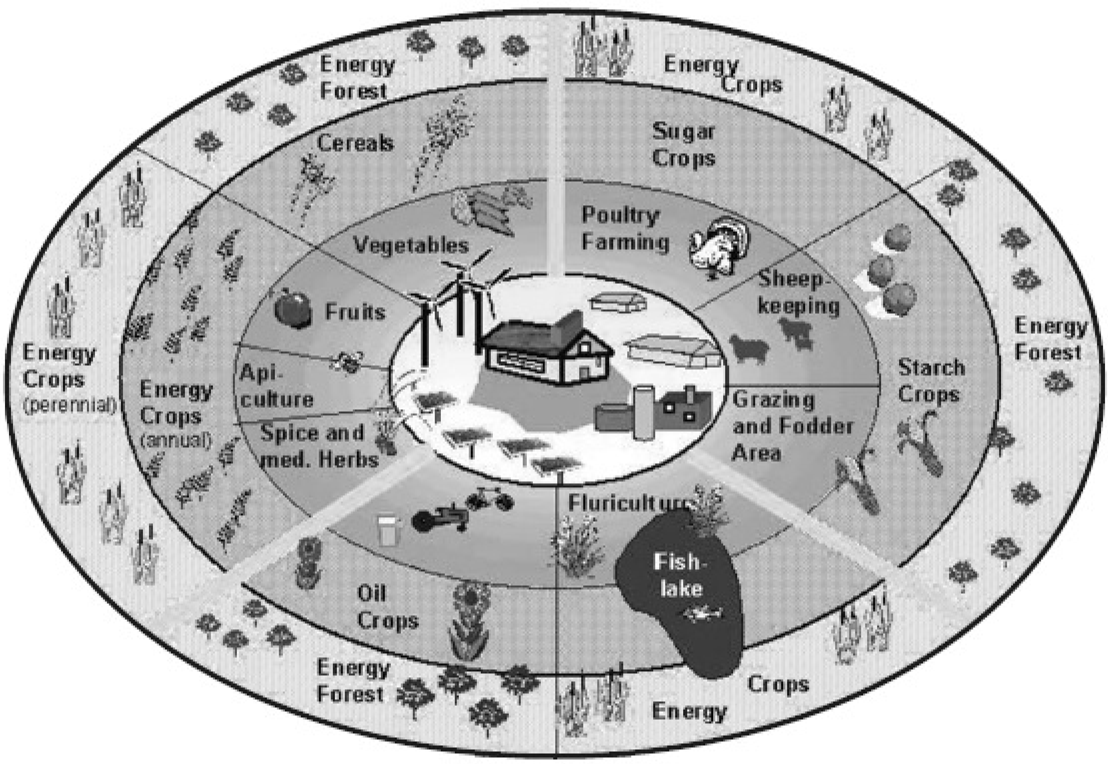

Figure 3: A model for an Integrated Energy Farm for, El Bassam 2001.

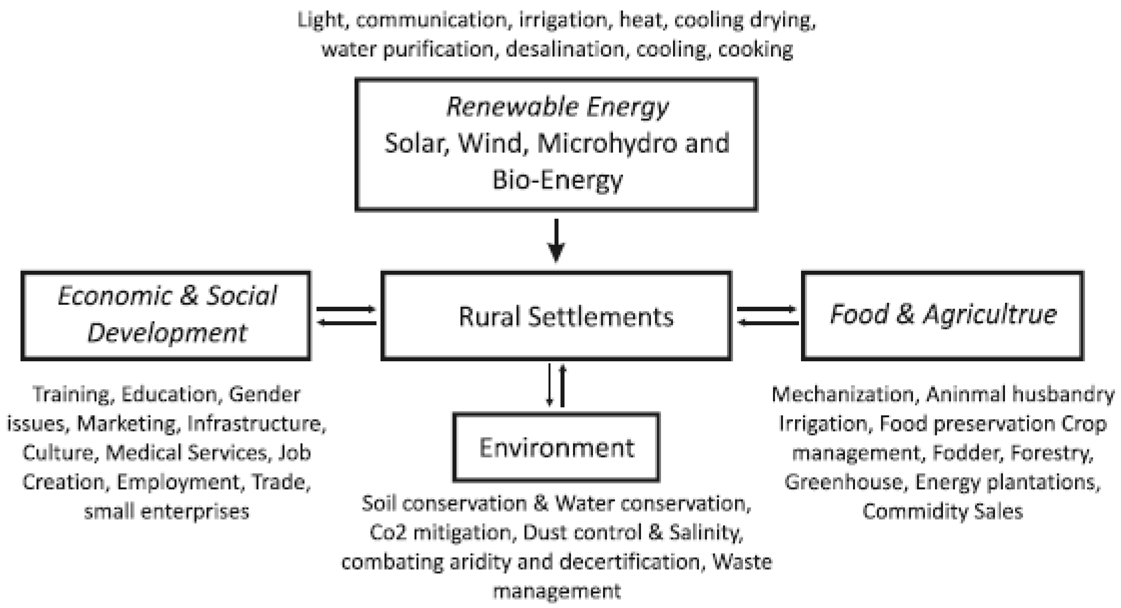

Figure 4: Pathways of the Integrated Energy Farms (IEF).

Implementation Procedure

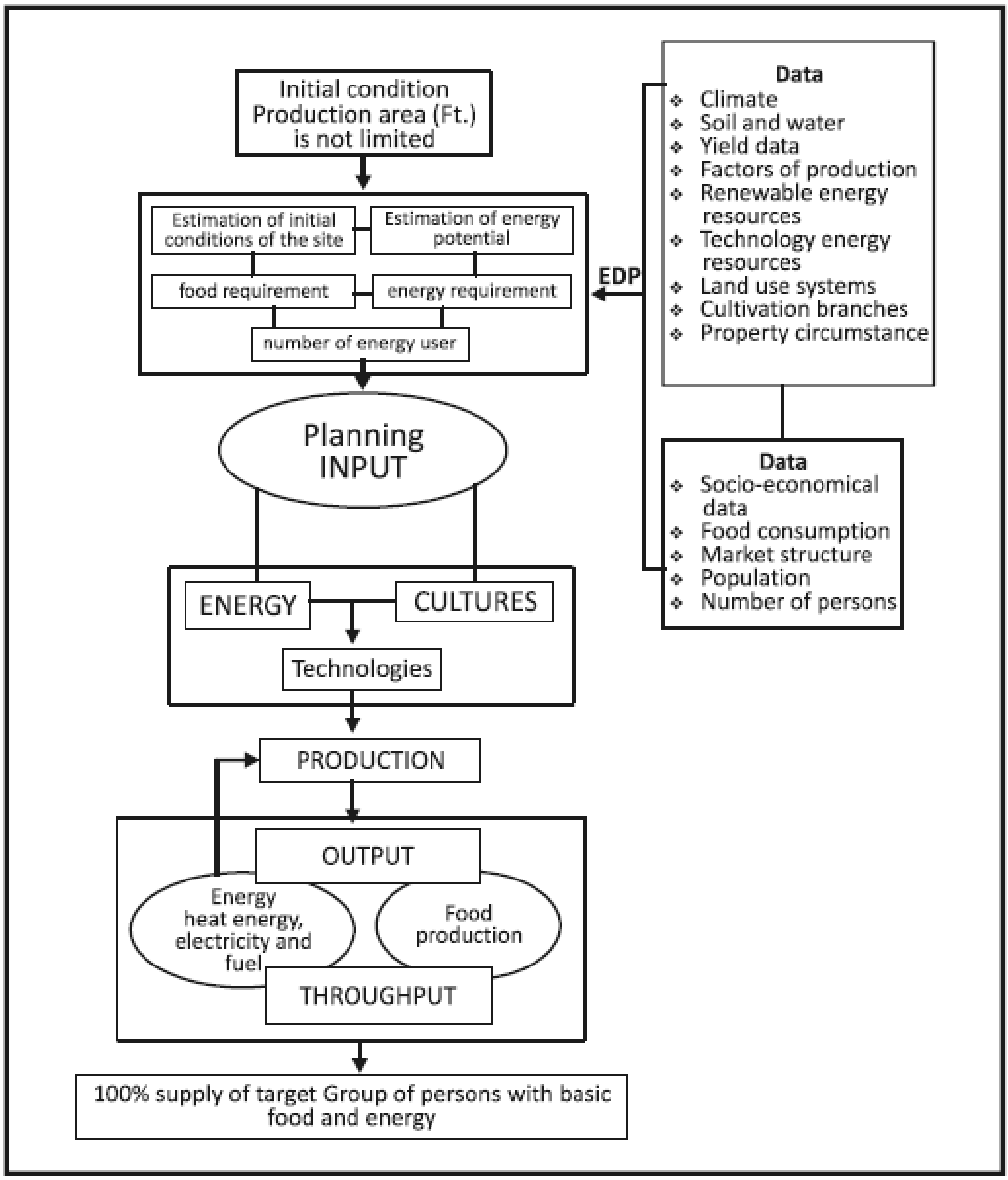

Figure 5: Projection steps of IEF.

Moving ahead, in order to broaden the scope and seek the practical feasibility of such farms, the dependence of local inhabitants (end users) is to be integrated in this system. Roughly 500 persons (125 households) can be integrated in one farm or rural settlement unit. They have to be provided with food as well as energy. As a consequence, the estimated extra requirement of 1 900 MWh of heat and 600 MWh of power has to be supplied from alternative sources. Under the assumption that the share of wind and solar energy in the complete energy provision remains at the same level, the production of 450 tonnes of dry biomass is needed to fulfil the demands of such farm units. For the production of this quantity of biomass, 20% of farm area needs to be dedicated for cultivation. In Southern Europe and the Equator, 15% of the land area should be made available for the provision of additional biomass.

Climatic conditions prevailing in a particular region are the major determinants of agricultural production. In addition to that, other factors like local and regional needs, availability of resources and other infrastructure facilities also determine the size and the product spectrum of the farmland. The same requisites also apply to an IREF. The climate fundamentally determines the selection of plant species and their cultivation intensity for energy production on the farm. Moreover, climate also influences the production of energy-mix (consisting of biomass, wind and solar energies) essentially at a given location; and the type of technology that can be installed also depends decisively on the climatic conditions of the locality in question. For example, cultivation of biomass for power generation is not advisable in arid areas. Instead a larger share can be allocated to solar energy techniques in such areas. Likewise, coastal regions are ideal for wind power installations.

Food and Energy Plantations

More than 50 crops have been identified in different regions of the world to serve as sources for biofuels. Selected crops which can be grown under various climatic conditions is documented in Tables 1, 2 and 3.

Table 1: Representative crops for temperate regions

Cordgrass (*Spartina* spp.)	Reed Canary Grass (*Phalaris arundinacea*)
Fiber sorghum (*Sorghum bicolor*)	Rosin weed (*Siphiun prifoliatum*)
Gaint knotweed (*Polygonum sachalinensis*)	Safflower (*Carthamus tincrorius*)
Hemp (*Cannabis sativa*)	Soybean (*Giycine max*)
Kenaf (*Hibiscus cannabinus*)	Sugar beet (*Beta vulgaris*)
Linseed (*Linum usitarissimum*)	Sunflower (*Helianthus annuus*)
Miscanthus (Miscanthus x giganteus)	Switchgrass (*Panicuni virgatum*)
Poplar (*Populus* spp.)	Topinambur (*Helianthus tuberosus*)
Rape (*Brassica napus)*	Willow (*Salix* spp.)

Source: El Bassam, 1996 and 1998b.

Table 1: Representative crops for temperate regions

Table 2: Representative crops for arid and semi-arid regions

Argan tree (*Argania spmosa*)	Olive (*Olea europaea*)
Broom (Ginestra) (*Spartiurm junceum*)	Poplar (*Populus* spp.)
Cardoon (*Cynara cardunculus*)	Rape (*Brassica napus*)
Date palm (*Phoenix dactylifera*)	Safflower (*Carthamus tinctorius*)
Eucalyptus (*Eucalyptus* spp.)	Salicormia (*Salicornia bigelovii*)
Giant reed (*Arundo donax*)	Sesbania (*Sesbania* spp.)
Groundnut (*Arachis hipogaea*)	Soybean (*Glycine max*)
Jojoba (*Simmondsia chinensis*)	Sweet sorghum (*Sorghum bicolor*)

Source: El Bassam, 1996 and 1998b

Table 2: Representative crops for arid and semi-arid regions

Table 3: Representative energy crops for tropical and sub-tropical regions

Aleinan Grass (*Echinochloa polystachya*)	Jatropha (*Jatropha curcas*)
Babassu palm (*Orbignya oleifera*)	Jute (*Crocorus* spp.)
Bamboo (*Bambusa* spp.)	Leucaena (*Leucaena leucoceohala*)
Banana (*Musa* x *paradisiaca*)	Neem tree (*Azadirachta indica*)
Black locust (*Robinia pseudoacacia*)	Oil palm (*Elaeis guineensis*)
Brown beetle gras (*Leptochloa fusca*)	Papaya (*Carica papaya*)
Cassava (*Manihot esculenta*)	Rubber tree (*Acacia senegal*)
Castor oil plant (*Ricinus communis*)	Sisal (*Agave sisalana*)
Coconut palm (*Cocos nucifera*)	Sorghum (*Sorghum bicolor*)
Eucalyptus (*Eucalyptus* spp.)	Soybean (*Glycine max*)
	Sugar cane (*Saccharum officinarum*)

Source: El Bassam, 1996 and 1998b

Table 3: Representative energy crops for tropical and sub-tropical regions

OUTLOOK

Measures to overcome the problems of food, water and energy supply in Developing countries are essential and continually attracting the attention of Governments, the international lending agencies, non-governmental organizations and the various stakeholders. This project is aiming to deepen the discussions, for the main purposes of elucidating the issues and finding the appropriate answers that will keep the world on a much more robust growth path, and towards achieving key targets of the MDGs. However, the great challenge facing sub-Saharan African economies is how to reduce poverty by half, before the year 2015, in line with the first objective of the Millennium Development Goals (MDGs). Specifically, the targets are to: reduce by half the proportion of people living on less than a dollar a day and as well reduce by half the proportion of people who suffer from hunger. In addition, Africa has multiple energy technologies to satisfy the needs of 30%

of the population, in urban areas. The rural areas, where the remaining 70% live, have limited energy choices. It must be a priority for African governments to ensure that the rural majority has access to the same choices as those who live in urban areas (Davidson and Sokona, 2001).

These goals call for GDP growth rates even higher than the current achievement. The implication is for higher levels of domestic investment and productivity of the economy. In order to achieve this goal, real GDP growth rates should be 7% or more per annum. Yet the productivity and overall performance of sub-Saharan African economies is being hampered by the state of the Energy Sector. Lack of energy services or poor access to this resource, are likely some of the factors militating against sub-Saharan African economies in achieving higher potentials of their economies.

Electricity accounts for only 4% of Sub-Saharan Africa's total energy consumption, yet it is a most vital input in the production processes and in the delivery of the social services, namely education and health care services.

Electric power is a catalyst for social and economic development. In Africa, electric energy is provided mainly from fossil fuels and hydropower. Electricity consumption is also the lowest, on a regional basis, at about 515 kwh/per annum compared to the world average of 2,326 kwh/per annum. Out of the total Sub-Saharan Africa population of 743 million, over 500 million or 67% lack access to electricity services. Also, the MDG goals in the education and health-care sectors are being compromised by the lack of electricity, as majority of schools and health-care centers cannot function properly. Inadequate lighting or illumination in schools is not conducive to learning. There is undue reliance on standby generators or kerosene lamps that are not safe. Africa Energy Commission (AFREC)

The importance of modern energy provision in African development cannot be over-emphasised, as it is the nucleus of socio-economic development worldwide. However, large numbers of Africans depend instead on firewood and charcoal, reflecting the comparatively low level of industrialisation on the continent. Moving out of this stage requires a substantial increase in cost-effective and affordable energy sources, while minimising environmental hazards and ensuring social equitability and sustainability. For Africa to be competitive, its per capita primary energy needs to be increased. In comparison with the rest of the world, Africans are among the smallest consumers of primary energy.

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