The University of Malawi
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BIOMASS ENERGY USE IN MALAWI

Prepared for International Institute for Environment and Development (IIED) by

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espa
ecosystem services
for poverty alleviation

Citation

Kambewa, P. and Chiwaula, L. (2010) Biomass energy use in Malawi. A background paper prepared for the International Institute for Environment and Development (IIED) for an international ESPA workshop on biomass energy, 19-21 October 2010, Parliament House Hotel, Edinburgh. Chancellor College, Zomba, Malawi.

Acknowledgements

This report was funded by the Ecosystem Services and Poverty Alleviation Programme of the UK Government Department for International Development (DFID), the UK Natural Environment Research Council (NERC) and the UK Economic and Social Research Council (ESRC). Additional IIED frame funds were used from the Danish International Development Agency (DANIDA), the UK Government's Department for International Development (DFID), the Directorate General for International Cooperation, the Netherlands (DGIS), Irish Aid, the Norwegian Agency for Development Cooperation (NORAD), Swiss Agency for Development and Cooperation (SDC), the Swedish International Development Agency (SIDA). Comments to earlier drafts by Duncan Macqueen and Bright Sibale are also acknowledged. The views expressed in this report do not necessarily represent those of the supporting institutions involved.

This report was prepared as one of five background reports for an international workshop on 19-21 October 2010 on biomass energy at the Parliament House Hotel, Edinburgh. The workshop was part of a UK ESPA programme Partnership and Project Development (PPD) Grant to build a consortium around a project on 'Biomass energy – Optimising its contribution to poverty reduction and ecosystem services'. The authors are grateful for the active discussion of the draft ideas by participants of that meeting.

Acronyms

BEST	Biomass Energy Strategy
BRAC	Benefits from Reducing Atmospheric Carbon
COMAP	Comprehensive Mitigation Analysis Process
ESCOM	Electricity Supply Corporation of Malawi
FAO	Food Agriculture Organization
FGLG	Forest Governance Learning Group
GDP	Gross Domestic Product
GHG	Green House Gases
GJ	Giga Joules
GoM	Government of Malawi
IHS	Integrated Household Survey
MERA	Malawi Energy Regulatory Authority
MGDS	Malawi Growth and Development Strategy
PCC	Petroleum Control Commission
PIL	Petroleum Importers Limited
t.w.e.	Total Wood Equivalent
TJ	Terra Joules
TOE	Tonnes of Oil Equivalent
w.e.	Wood Equivalent

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Executive summary

This paper presents the status of biomass supply and utilisation in Malawi as well as the policies and projects that promote and regulate biomass production and utilisation. The paper is based on secondary research and published and unpublished documents were review. A number of issues have emerged as regards to biomass production and utilisation and these are summarised below:

Biomass is the main source of energy in Malawi. It accounts for 97% total primary energy supply out of which 59% is used in its primary form as firewood (52%) and residues (7%), while the remaining 41% are converted into charcoal. The annual sustainable supply of all biomass is estimated at 42.4 million cubic metres of solid wood equivalent (w.e.). This is some 2.7 times current demand of energy in Malawi. The effect of spatial distribution of biomass energy supply results in the inaccessibility of the seemingly surplus biomass energy. For example, there are large surpluses in northern Malawi, but these are neither economically nor physically accessible to the bulk of the population living in the centre and the south because of high transportation costs. Therefore any efforts to improve production of biomass as a source of energy in the country should concentrate in the central and southern Malawi where there is more pressure than the northern region. At the same time, programmes addressing biomass energy in the north should concentrate on sustainable use of the existing resources. Some trees are also in national parks or other protected areas which legally cannot be exploited as a source of energy. As a result, while there is an excess of biomass nationally, rates of harvesting are well in excess of sustainable supply in the country's main urban catchments around Lilongwe and (particularly) Blantyre and Zomba.

The gross annual energy demand in Malawi is estimated at 155,775 Tera Joules. Biomass accounts for 88.5% of this energy demand. Other important sources of energy are petroleum (6.4%), electricity (2.8%) and coal (2.4%). The total demand for biomass energy is estimated at 8.92 million total wood equivalent (t.w.e.) or about 13.38 million cubic metres of solid wood (or 24.3 million cubic metres of wood stacked). Almost all of Malawi's current demand for biomass energy is met from indigenous and renewable resources. There are remarkable differences in biomass energy consumption between rural and urban areas. Biomass energy is more important for rural households than it is for the urban households. About 95% of total energy consumption in the rural area comes from firewood compared to 55% in the urban areas. Almost all the energy consumed in rural areas is from biomass compared to 89% in urban areas.

Biomass demand and supply projections show that biomass supply would reduce over the years while demand will increase due to increase in population. The likely impacts of the decline in biomass supply and increase in biomass demand on poverty, the ecosystem and demand for energy from other sources have not been assessed. However with population increasing at the current rates, this can only mean that cost of the biomass energy is likely going to increase to the disadvantage of especially the rural poor.

Biomass makes significant contributions to the national economy but this is underestimated in official statistics. The value of charcoal produced in Malawi is estimated at US$57 million while firewood is estimated at US$117.2 million. Overall, it is estimated that forestry sector's contribution to the country's GDP is 6.1%. At household level, biomass has been an important means of livelihood to many Malawians for a long time. The forestry sector employs a lot of

people additional to those in the informal sector, and those involved in fuel wood supply chain. Apart from offering employment, biomass is also a source of income for many people at different stages of the value chain.

In Malawi, biomass availability and utilisation is also related to some cultural practices and landscape integrity. There are a number of cultural practices that require some secrecy and hence requires thick forests. Some of these include initiation ceremonies, cults (such as *Mbona* cults in Nsanje district), graveyards, and *dambwes* (camps for traditional dancers among the chewas known as *gulewamkulu*). Since these require thick forests, they result in maintaining forests and also preserving biodiversity. Additionally, forests are used by traditional healers such that recent deforestation countrywide has resulted in scarcity of medicinal trees. As a result, the cost of traditional medicine has gone up compared to the past. Wanton cutting of trees has also led to the loss of integrity of the landscape.

There are three main policies that have bearings on biomass energy availability and utilisation in Malawi. These policies include the National Energy Policy, Forestry Policy and the Biomass Energy Strategy. The objectives of the Malawi energy policy include improving efficiency and effectiveness of the commercial energy supply industries; improve the security and reliability of energy supply systems; increase access to affordable and modern energy services; stimulate economic development and rural transformation for poverty reduction; improve energy sector governance; and mitigate environmental, safety, and health impacts of energy production and utilisation. The forestry policy is concerned with production of wood resources in man-made plantations, woodlots, and natural woodlands. On the other hand, the Malawi Biomass Energy Strategy's overall objective is to ensure a sustainable supply of affordable woodfuels.

A number of institutions define the biomass sector in Malawi. These include those that regulate production and use of biomass energy, those that produce biomass energy, and those that produce alternative sources of energy. There are also other organisations that are not directly involved with the use of biomass but their involvement is on advocacy, providing regulatory framework, and training and research. Innovative projects in biomass use in Malawi include the Blantyre fuelwood project whose main objective was supplying of affordable fuelwood to the urban poor; D & S Gelfuel Company that marketed gelfuel stoves and gelfuel to discourage households from relying on charcoal; the Improved Forestry Management for Sustainable Livelihoods (IFMSL) that was funded by the European Union, which supported households that live near forests with some livelihood activities so they should diversify away from exploiting trees in the reserves; and biodiesel projects that include the JANEEMO project and the Jatropha project. In general the policies and projects have aimed at reducing pressure on existing biomass energy resources through promotion of utilisation alternative energy sources, promotion of alternative livelihood sources, and prudent management of existing biomass resources.

1 Status of biomass supply and utilisation

1.1 Biomass energy supply and demand

In Malawi biomass is the main source of energy for the majority of the population. This is the case because of high poverty levels as well as low coverage of electricity and other alternative sources of energy (Yaron et al., 2010). With about 40% of Malawians living below the poverty levels, access to and use of electricity and other non-biomass forms of energy remains low. Biomass accounts for 97% of total primary energy supply of which 59% is used in its primary form as firewood (52%) and residues (7%), while the remaining 41% are converted into charcoal. According to the 2008 population and housing census[1], 43.4% of all households in urban areas used charcoal for cooking, 41.8% used firewood for and only 13.6% used electricity for cooking. Both charcoal and firewood are obtained from products from different forest and land tenure arrangements, which include government forest plantations and forest reserves, private forest plantations and indigenous wood (customary land).

A recent participatory assessment of livelihoods in the Upper Shire Catchment indicated that charcoal is a more convenient and higher value fuel than firewood and hence it is mainly used by middle- and upper-income families in urban areas (Millennium Challenge Corporation, 2010)[2]. In the same study, women interviewed in urban areas reported that they preferred using charcoal for cooking as it is does not produce smoke and soot, while women in rural areas preferred using firewood because of the high opportunity cost of charcoal. Biomass energy sources include wood from different tenure systems which include public (government) forest plantations and forest reserves, private forest plantations, open customary land and individually owned farms, wastes from wood industry, agricultural residues from customary land and tobacco estates, and agro-industry residues. It is reported that more than a third of biomass resources (34%) is obtained from agricultural and industrial residues (GoM, 2003).

It is estimated that the annual sustainable supply of all biomass is 42.4 million cubic metres of solid wood equivalent (w.e.). This is produced from an estimated annual growth of stem of 29.8 million cubic metres of solid wood and the additional annual production of crop residues and dung (12.1 and 0.5 million cubic metres solid w.e., respectively). This is some 2.7 times current demand of energy in Malawi (15.8 million cubic metres) (Malawi BEST, 2009) which reflects that there is a seemingly surplus supply of biomass. The Forestry Department estimates that mobile saw millers and pit sawyers extracted an estimated 199,603 cubic metres of wood, mainly for the purpose of timber, worth about MK159.7 million (US$1.14 million) in 2007. In 2008, these extractions were estimated at 83,520 cubic metres worth MK91.9 million (US$0.66 million) (GoM, 2008, 2009). However, these estimates are based on the Department's own sales of trees and logs, and exclude sales by private plantation holders, which are quite limited that is why these estimates are lower than the estimates that are produced by Food and Agricultural Organization (FAO) and the Malawi BEST. The FAO reports that 5,760,100 cubic metres of roundwood was produced in 2007, while the Malawi BEST (2009) shows that 14,895,000 cubic

[1] Government of Malawi, National Statistics Office, 2008, Population and Housing Census
[2] Millennium Challenge Corporation, 2010. Baseline Assessment of the Upper Shire and Lake Malombe Catchment Area by LTS International

metres of roundwood is consumed annually, of which 13,643,000 cubic metres is in the form of woodfuel (firewood and charcoal wood), and the rest is for poles and sawnwood (Table 1).

Table 1: Annual use of roundwood in Malawi, 2007

Forestry resource use	Total consumption('000cubic metres /year)	Contribution to total consumption (%)
Charcoal[1]	1,999	13
Firewood[1]	11,644	78
Poles	975	7
Sawnwood	280	2
Total roundwood	14,895	100

Source: Malawi BEST (2009)
Notes: [1.] Figures include consumption by industrial and transport sectors
A shadow exchange rate of MK148.00 = US$1.00 was assumed in BEST (2009)

In terms of consumption, the Government of Malawi (2003) reports that in 1996, the annual per capita energy consumption was estimated at 12.5 GJ, or 0.29 TOE. This is lower than the per capita average of 80GJ for upper-middle income countries and over 200 GJ in high income economies. Recent estimates from the Malawi BEST (2009) study show that gross annual energy demand in Malawi was at 155,775 Tera Joules. Biomass accounted for 88.5% of this energy demand which is slightly lower than the 93% in 2000. Other important sources of energy are petroleum (6.4%), electricity (2.8%) and coal (2.4%). In 2008, the total demand for biomass energy was 8.92 million total wood equivalent (t.w.e.) or about 13.38 million cubic metres solid wood (or 24.3 million cubic metres of wood stacked), and that almost all of Malawi's current demand for energy was met from indigenous and renewable resources. The household sector accounted for over 90 % of this demand (Malawi BEST, 2009).

Table 2 below further shows that out of the total energy demand, households demand the majority (83.4%) of it followed by Industry (11.7%) and then transport (3.8%).

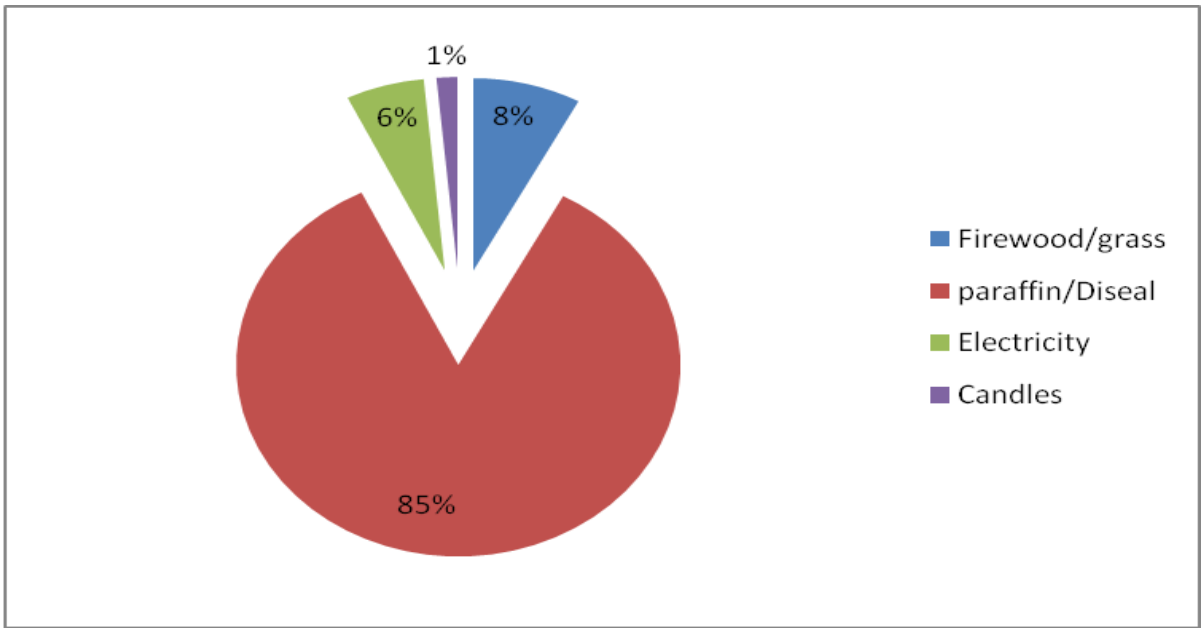
Table 2: Total national energy demand in Malawi, by sector and fuel type

Sector	Energy demand by fuel type (TJ/yr)					
	Biomass	**Petroleum**	**Electricity**	**Coal**	**Total**	
Household	127,394	672	1,798	5	129,869	83.4%
Industry	9,664	3,130	2,010	3,481	18,285	11.7%
Transport	270	5,640	35	15	5,960	3.8%
Service	452	558	477	174	1,661	1.1%
Total	**137,780**	**10,000**	**4,320**	**3,675**	**155,775**	
	88.5%	6.4%	2.8%	2.4%		

Source: Malawi BEST (2009)

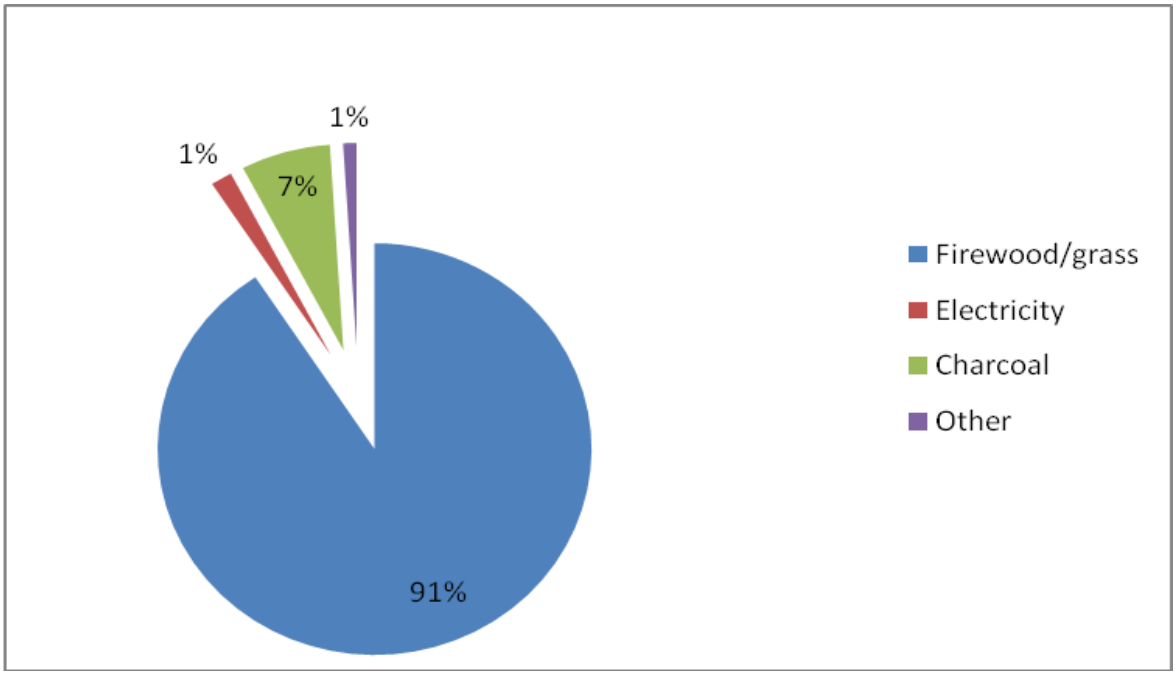
Annual household energy consumption in 2008 was 130,046 Terra Joules and biomass represented about 98% of total household energy demand. Electricity is the second most important source of energy at household level. These results agree with the data from Malawi's Second Integrated Household Survey (IHS2) which shows that the household sector is the dominant energy user, accounting for about 84% of total consumption. The agriculture sector uses 8% of the energy and this is followed by the transport sector (4%) and the industrial sector (2%) demand the least. Figure 2 below gives the sources of energy for different purposes in the households. Further to that, the IHS2 also show that Biomass is the major energy source for Malawian households.

Figure 1: Energy sources for household lighting in Malawi



Source: Own illustration from the Malawi Second Integrated Household Survey

Figure 2: Energy sources for household cooking in Malawi



Source: Own illustration from the Malawi Second Integrated Household Survey

Figure 2 shows that paraffin is the major source of energy for lighting in households in Malawi. About 85% of the households in the survey reported that paraffin is their energy source for lighting. Only 8% of households use biomass energy in the form of firewood and grass to light their houses. Another 6% reported that they use electricity to light their houses. On the other hand, Figure 3 shows that up to 98% of the households use biomass in the form of firewood (91%) and charcoal (7%) for cooking. It is clear that biomass is a mostly used for cooking and not lighting houses.

Biomass demand and supply projections show that biomass supply would reduce from 300 million tonnes in the year 1990 to about 190 million tonnes in 2030 (Kambewa et al., 2007). This is the case because of the depletion of the biomass such that the replenishment does not catch up with increased demand. The likely impacts of this decline on poverty, the ecosystem and demand for energy from other sources were not been assessed. However with population increasing at the current rates, this can only mean that cost of the biomass energy is likely going to increase to the disadvantage of especially the rural poor.

1.2 Geographical dimensions of biomass energy supply and demand

There are remarkable differences in the energy consumption between rural and urban areas as shown by Table 3 and Figure 4 below.

Table 3: Household energy consumption in rural and urban Malawi in 2008 (TJ/yr)

Source of energy	Amount of energy (TJ per year)			
	Rural	Urban	National	
Firewood	105,320	10,560	115,880	89.1%
Charcoal	2,360	6,340	8,700	6.7%
Residue/dung	2,980	11	2,991	2.3%
Electricity	70	1,728	1,798	1.4%
Paraffin	240	430	670	0.5%
Coal	0	5	5	0.0%
LPG	0	2	2	0.0%
Total	110,970	19,076	130,046	100.0%

Source: Malawi BEST (2009)

Table 3 shows that total rural energy consumption at household level is 110, 970 TJ/year and this is much higher than the urban consumption of 19,076 TJ/year. This is in order because over 80% of the population in Malawi is in the rural areas. Biomass energy is the more important energy source for the rural households than it is for the urban households and most of it is used in its raw form. It can be shown that from Table 3 above that about 95% of total energy consumption in the rural area comes from firewood compared to 55% in the urban areas.

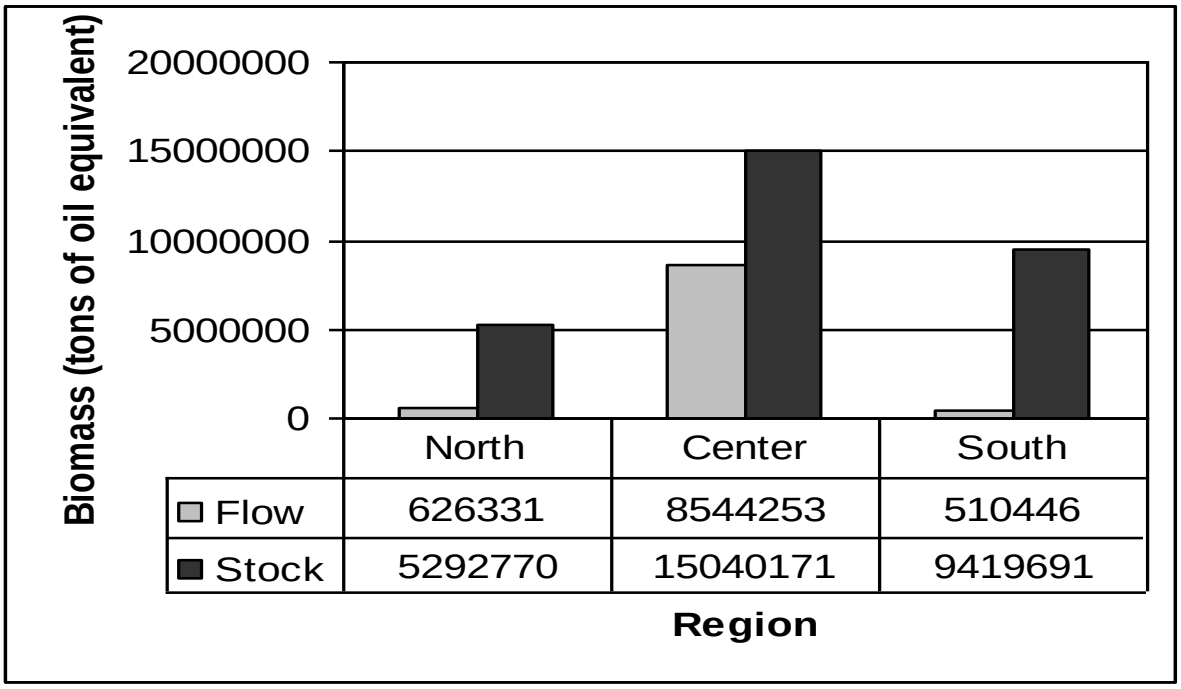
Almost all the energy consumed in rural areas is from biomass compared to 89% in urban areas. This is in line with IHS2 data which shows that almost all (97%) rural households use firewood and grass for cooking, while 1% uses charcoal and another 1% uses crop residues. There is therefore a 99% dependency on biomass energy for cooking in rural areas. In urban areas, charcoal is the mostly used energy source for cooking. The results show that about 44% of the urban households use charcoal for cooking, 33% of the households use firewood, while 10% use electricity. It therefore implies that 87% of urban households depend on biomass energy for cooking.

When it comes to lighting IHS2 data shows that about 89% of the households in the rural areas use paraffin/diesel as a source of light energy, 8% use grass and firewood, while only 2% use electricity compared with their counterparts in the urban areas where 59% use Paraffin and Diesel, 32% use electricity, while 8% use candles. Use of firewood and grass to light households in the urban areas is almost nonexistent. These results are closer to a recent study by Yaron et al. (2010) which reports that firewood provides 95% of rural household energy supply and 55% for urban household energy supply while charcoal is providing around a third of urban household energy supply.

The effect of spatial distribution of biomass energy supply results in the inaccessibility of the seemingly surplus biomass energy. For example, there are large surpluses in northern Malawi, but these are neither economically nor physically accessible to the bulk of the population living in the centre and the south (see Figure 3 and 4) because of high transportation costs. Therefore any efforts to improve production of biomass as a source of energy in the country should concentrate in the central and southern Malawi where there is more pressure than the northern region. At the same time, programmes addressing biomass energy in the north should concentrate on sustainable use of the existing resources. Some trees are also in national parks

or other protected areas which legally cannot be exploited as a source of energy. As a result, while there is an excess of biomass nationally, rates of harvesting are well in excess of sustainable supply in the country's main urban catchments around Lilongwe and (particularly) Blantyre and Zomba (Malawi BEST, 2009).

Figure 3: Distribution of biomass resources by administrative region, 1988



Source: Government of Malawi, 2003

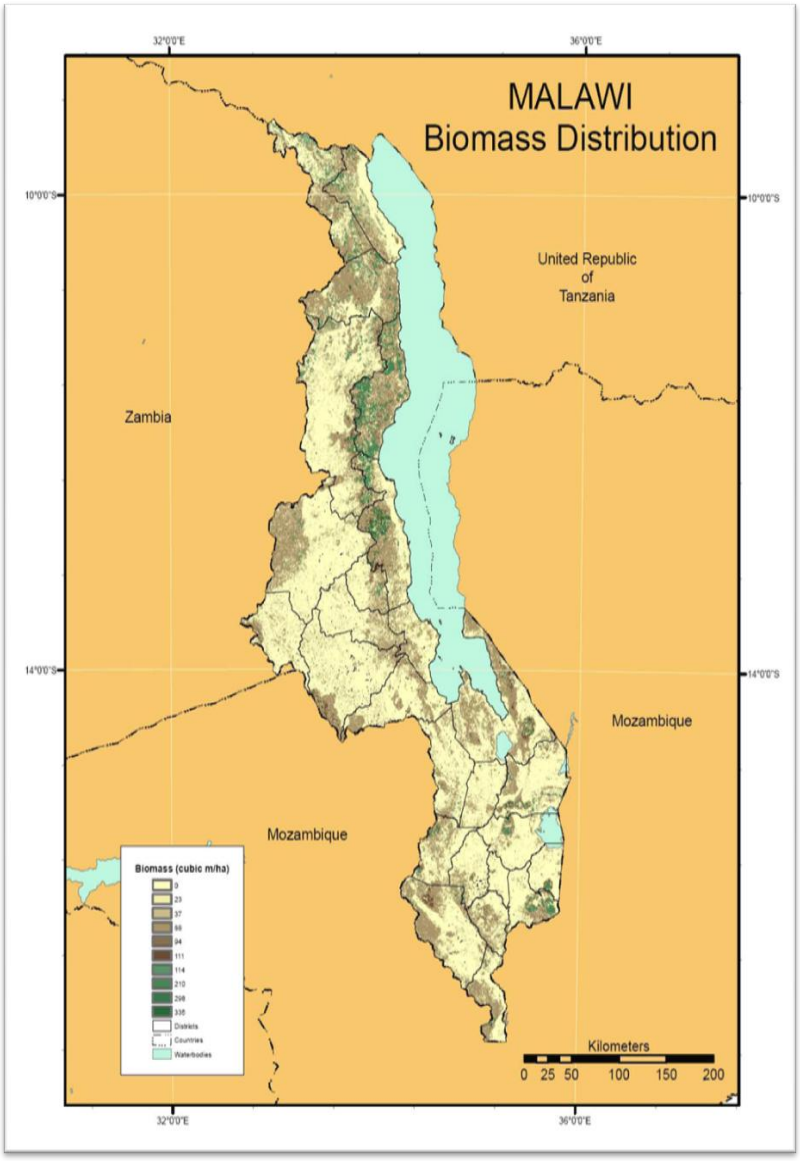
1.3 Impacts of yield of biomass crops on forest conversion to agriculture

The wood resource base is diminishing, principally because woodlands and trees are being cleared to open up new land for farming mainly because of population pressure. This is exacerbated by the fact that the public extension system faces multiple capacity and financing challenges that limit its impacts in terms of delivery of forestry, agricultural and general environmental education in Malawi. In addition, there are conflicting policies, especially between the agricultural sector and the environment and natural resources management sector. For example, between 1991 and 2008, an estimated 669,000 hectares of woodlands were converted to agriculture while over 70 million cubic metres of wood were cleared for agricultural expansion. In 2008 alone, the area cleared was estimated at 45,000 hectares. The diminishing standing stock is resulting in a gradual reduction in the amount of biomass that can be sustainably harvested each year (Malawi BEST, 2009).

The unfortunate situation in Malawi is that traditional biomass used for energy, especially firewood and charcoal, are from naturally growing trees with very few cases of people

deliberately growing trees as a source of biomass energy supply. However there are documented crop species which can be grown for biomass energy supply. These include Jatropha and soybeans. It is assumed that if these were to supply biomass for energy, there would be a reduced need to exploit the slow growing natural indigenous trees. The major challenge though to the promotion of these crop species is the competition they face for land with food and cash crops.

Figure 4: Biomass distribution at the year 2004 derived from remotely sensed data recorded by MODIS sensor



Source: Bandyopadhyay et al., 2006

2 Biomass energy and the economy in Malawi

The current use of biomass energy has been blamed for the country's environmental degradation especially deforestation. A recent study indicated that unsustainable fuel wood had an annual cost of US$44 million on the country's economy representing 1.2% of the country's GDP (Yaron et al., 2010). The study indicated that although official figures indicate that the forestry sector contributes only 1.8% to the country's GDP, the inclusion of firewood and charcoal gives an additional 4.3%. The forestry sector's contribution to the country's GDP is therefore 6.1%. Kambewa et al. (2007) estimated the value the charcoal sold in the four cities in Malawi at US$41.3 million which was about 0.5% of the country's GDP[3]. Malawi BEST (2009) gave an estimated value of charcoal produced in Malawi at US$57 million while firewood was estimated at US$117.2 million. The various studies therefore indicate that biomass energy sources contribute significantly to the country's economy.

This section focuses on the impact of biomass use in various sectors such as poverty reduction, carbon sequestration, biodiversity and ecosystem resilience among others. Currently, the official figures from the National Statistical Office do not include green values as suggested by the quoted studies. Thus the contribution of biomass to the country's economy is underestimated. Furthermore, although some activities are illegal, e.g. charcoal trade, their contribution to the economy cannot be ignored.

2.1 Role of biomass energy in poverty reduction and household livelihood improvement

Biomass has been an important means of livelihood to many Malawians for a long time. A survey in Malawi in 1996/7 (Openshaw, 1997) estimated that 3,800 'full-time' people (assuming a 'standard' year of 2,400 hours) were involved in tree growing; 24,560 in fuelwood and charcoal (woodfuel) production; 9,570 in transport; and 18,100 in roadside and urban trading for the four principal towns of Blantyre, Lilongwe, Mzuzu and Zomba. This gives the combined total of 56,030 people employed. The estimated country total for 1996 was 93,480 full-time people involved in biomass, of which 87,070 were involved in production, transport and trade (Openshaw, 1997). Openshaw (1997) and Lowore (2006) reported that trade in wood fuel in the country's four cities provided 55,000 part time employments valued at US$43.7 million.

The current biomass use is a means of livelihood to a significant proportion of the population. The Malawi BEST study estimated that the forestry sector, a major source of energy employs about 29,000 people with 20,000 in the informal sector and 130,000 people involved in fuel wood supply. When combined with part time traders in wood fuel the number of people commercial fuel production could be in the region of 180,000 to 200,000. This is a significant number given that formal employment is very low in the country. Kambewa et al. (2007) reported that 92,800 people were involved in the value chain of charcoal as producers, transporters and wholesale and retail traders for the country's four cities. Among the producers, 38% were large scale producers, 27% medium scale and 35% small scale producers.

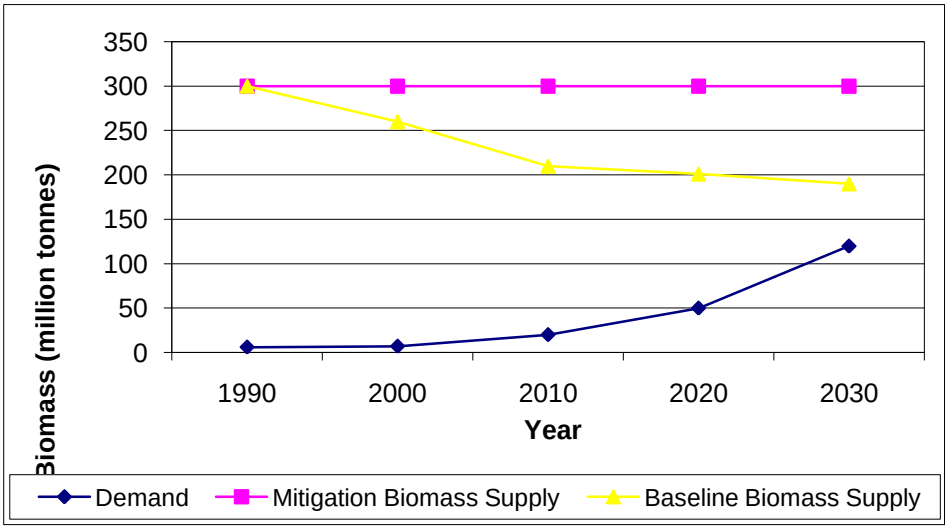
[3] Blantyre, Lilongwe, Mzuzu and Zomba Cities

As far as income from biomass supply is concerned, Malawi BEST (2009) estimated that labour costs for charcoal and firewood sold in the urban sector was valued at US$148 per day. This is significantly higher than other livelihood activities people can use in the country therefore providing an incentive enough for further exploitation of resources. The various studies therefore show that exploitation of biomass through production of charcoal or/and selling firewood have implications of reducing poverty among the people as suppliers of products, as well as consumers who have relatively cheaper source of energy since they cannot afford or access other sources of energy such as electricity and petroleum based sources.

2.2 Role of biomass use on carbon sequestration

This section is based on Kambewa et al. (2003). In countries where biomass is the major source of energy such as Malawi, one factor to be taken into account is the effect of biomass use on carbon sequestration. Increased biomass use as a source of energy means that the country's ability to sequester carbon gets reduced. In Malawi a study was carried out to determine the impact of the then biomass use on biomass supply for a period up to 2030. Further analysis was conducted to assess demand projections and effect of using alternative mitigation measures such as using short rotation, conserving existing forests and natural regeneration that can lead to the reduction in emission of GHG. Figure 5 below shows biomass supply and demand projects from 1990 to 2030 comparing baseline supply and supply with mitigation measures.

Figure 5: Overall biomass supply and demand projections



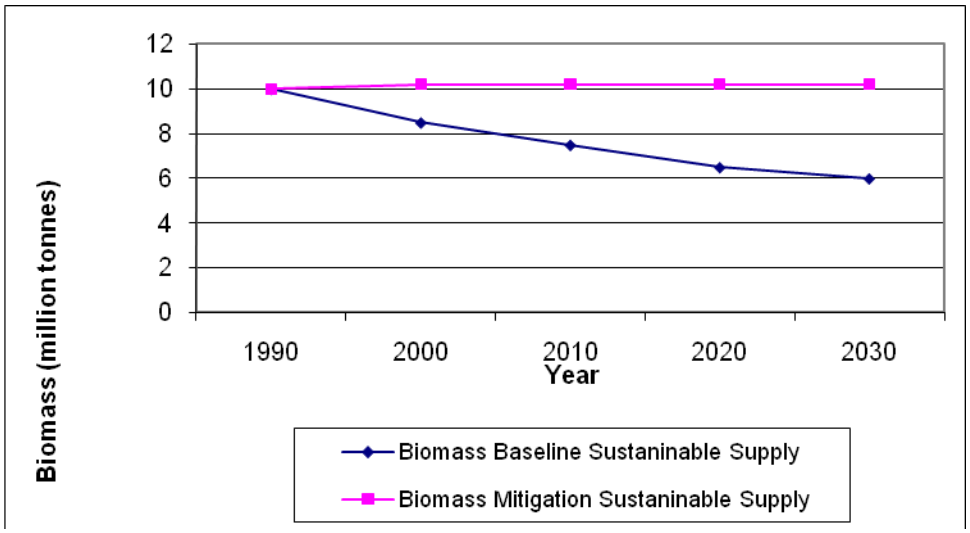
Source: Kambewa et al., 2003

Under baseline scenario, biomass supply is expected to keep declining over time while demand will keep on increasing in part due to increase in population. After the year 2030, the supply and demand will be approaching each other implying massive deforestation. However with mitigation measures put in place, the supply of biomass is expected to remain at 300 million tonnes. During the same period, wood demand is expected to increase sharply to about 17

times above the sustainable supply. Thus, if the rate of increase for demand does not change, the entire biomass stock could theoretically be consumed. Scot (1996) observed that re-planting and growing trees in degraded areas would reduce this deficit. The sustainable supply is about 3.51% of the total biomass.

While the figure above is showing that demand and supply are going to exceed 100 million tonnes per year, Figure 6 below shows that sustainable supply of biomass under baseline and under mitigation measures are below 10 million tonnes. This shows that Malawi is using biomass far above its sustainable levels.

Figure 6: Sustainable supply of biomass under baseline and mitigation scenarios



Source: Kambewa et al., 2003

In Figure 6 the sustainable supply reaches the maximum value at about 11 million tonnes under mitigation scenario by 2030. Under the baseline scenario, sustainable fuelwood declines to 7 million tonnes by 2030. These results suggest that the introduction of mitigation does not seem to prevent fuelwood crisis but only delays its occurrence. To increase the lag period, the current trends of consumption should be kept constant.

The main purpose of forestry mitigation options is to promote carbon storage, which would reduce atmospheric accumulation and delay its impact on global climate. Brown et al. (1995) noted that there were three basic types of mitigation are applicable to Malawi namely natural regeneration, forest protection and use of short rotation.

2.1.1 Use of natural regeneration as a mitigation measure

This mitigation measure determines potential for carbon sequestration through promotion of natural regeneration in degraded forests, soil, vegetation and litter. In order to determine the effect of this mitigation measure, there is a need to determine the amount of land available for promotion of natural regeneration, rate of carbon sequestration in the soil, vegetation and litter,

and the cost of protection, monitoring *vis-à-vis* the benefits from timber, fuelwood and non-timber products. A forty-year period was used (1990 to 2030). Consequently, the outputs from the Comprehensive Mitigation Analysis Process (COMAP) are the amount of carbon sequestered per hectare and the total area, the annual and total incremental carbon sequestered and the cost effectiveness of the mitigation measure. Four main assumptions under this mitigation options were:

- The amount of land that is regenerated was pegged at 60,000 hectares per year;
- amount of carbon added per year is 2.4 tonnes per hectare per year (dry weight increment) with carbon density of 0.45%;
- amount of carbon stored in the soil is 1.25 tonnes per hectare per year and
- the base scenario is a wasteland with the mitigation measure as reclamation of the wasteland.

2.1.2 Forest protection

Under forest protection, it is assumed that without protection, some of the forest land will be converted into agricultural use such that the hectarage for forest will decline in due course at 0.3% while under the mitigation scenario, the amount of land under forest is the same. The benefits under the baseline scenario decrease at 0.3% while the benefits under the mitigation scenario increase at 8.2%. In this study, the initial amount of land under protected forest was 1,851,531 hectares. Where there is no protection, the biomass carbon decreases by 0.3% per annum while under mitigation scenario the biomass carbon increases by 1% per annum. Additionally, the mitigation scenario attracts the initial costs and cost of monitoring. With forest protection, there are benefits arising from conversion of land into agriculture at K1, 500 per hectare, which is not realised with protection.

2.1.3 Short rotation forest

Under short rotation, the specific land is placed under some trees for rotation within a short period. Every year, about 60,666 hectares are subject to short rotation. Carbon is sequestered from the soil, vegetation litter and other products. The benefits from the forest include the timber products, fuel-wood products such as charcoal and non-timber output (resin, honey and fruits). Table 4 shows the cost effectiveness of the three mitigation measures.

Table 4: Annual cost of various mitigation measures

Scenario	**Total Hectare Available**	**Cost per hectare**	**Total Cost (K'000,000)**	**Net Present Benefit K/t-C**
Natural Regeneration	60,000	10,490	629.4	0
Forest protection	1,851,351	110	203.7	56.31
Short rotation	60,666	29,730	1,803.6	2506.9
Total	**1,961,351**	**-**	**2,636.7**	**-**

Source: Kambewa et al., 2003

While the forest protection has the least cost per hectare, the area it covers is the largest - over thirty times as much as the natural regeneration measure. This suggests that it would take about 30 years for the natural regeneration option to cover as much area as the area currently being covered by the forest. If the government were to implement all the three options it means that on top of the existing 1.8 million hectares under forest at the moment, an addition land of 120,000 hectares would be converted to forestry every year thereby increasing Malawi's capacity to sequester carbon. However, this has serious budgetary implications. For instance, it would cost the country K2, 637 million per annum to fund all three mitigation measures. Furthermore, it should be noted that the most expensive mitigation measure, short rotation whose cost is MK29,730 per hectare is also the most effective bringing in net present benefit of MK2,506.9 per tonne of carbon sequestered.

2.2 Role of biomass use on biodiversity and ecosystem resilience

Deforestation has impact on biodiversity depending on the use of the biomass. Some biomass use is non-selective while some use tends to be selective. For instance, charcoal makers tend to have preferred species. Hence as long as charcoal is being made, the preferred species become targeted and therefore endangering the preferred species. Kambewa et al. (2007) showed that in Choma and Dzalanyama Forest Reserves the preferred species for charcoal production were still present as dominant or important species. However in other sites, different species had assumed dominance and importance implying that species composition was altering. However the absence of preferred species did not stop people from making charcoal. The report further noted that the vegetation of plateaus and escarpment areas of Zomba Mountain which were *Zambezian* miomboland were in transition to *Zambezian* undifferentiated woodland. A study carries out by Ngalande (Undated) also suggests that there is species composition changes in areas where biomass harvesting is significant.

2.3 Role of biomass use on watershed dynamics and flows

Biomass use has both onsite and off-site impacts which have to be taken into account. In Malawi, the most documented are off-site impacts on lost hydro electricity generation, drinking water treatment costs and flood prevention. Biomass use affects watershed through soil erosion effects since land remains unprotected after trees have been removed. The picture below shows degraded uplands in central Malawi which has effects downstream.

Figure 7: Degraded sparse forest area in Malawi

In Southern Malawi, the activities upstream such as cultivation and deforestation have lead to impacts in the Mid and Lower Shire which has affected electricity generation, water production for the city of Blantyre and irrigation in the Lower Shire.

The Electricity Supply Corporation of Malawi (ESCOM) observed that due to environmental degradation and bad farming practices in the catchment area of the Mid Shire area and its tributaries, large quantities of silt are deposited in the station's reservoirs thereby reducing live storage capacity.

Photo source: http://renegadeconservatoryguy.co.uk/wp-content/uploads/2010/07/deforestation_malawi4.gif

Yaron et al. (2010) estimated that annual cost of soil erosion on hydropower totalled US$10 million or 1.9% of the country's GDP. The same study indicated that soil erosion cost the Blantyre Water Board US$415,949 in 2008 and that with increased turbidity the cost would increase. Additionally, it is observed that soil erosion occurrences in the mid and upper Shire was causing siltation in the Lower Shire affecting irrigation farming with about half of the treadle pumps and canal based irrigation not functioning because of siltation. Since the study only concentrated in only one part of the country, it is likely that the cost of deforestation is significantly larger than reported. For instance, the analysis did not include effect on the fishing industry.

2.4 Biomass use, cultural practices and landscape integrity

Biomass use affects some cultural practices and landscape integrity in various ways. On the cultural front there are three areas where this is true.

- Among the Chewa and Nyanja tribes, they have a dance which is closely associated with initiation ceremonies[4]. These are performed in the graveyard. Such graveyards are usually thick forests aimed at maintaining the secrecy that goes along with the initiation ceremony and the dance itself. Culturally it is prohibited to cut down trees in the graveyard and any violations meet with stiff penalties.

- The Mbona cult, practiced in Nsanje district in Khuluvi forest also relies on biomass. Here the Mang'anja pray for rain and the forest is used for making sacrifices praying to Mbona. Praying for rain and making sacrifices used to be practiced country-wide; this practice still carries on at this location, but is dead in other areas, as it is deemed un-Christian. The forest is a sacred site which said to be full of spirits who guard the resting place of Mbona. An old woman is committed to the forest as Mbona's wife.

- With recent deforestation countrywide, it is said that traditional healers have to travel long distances in order to access roots, barks and leaves which have medicinal properties. As a result, the cost of traditional medicine has gone up compared to the past due to the scarcity of the trees.

- Wanton cutting of trees has led to the loss of integrity of the landscape. In a recent study by Yaron et al (2010) it was observed that the cutting of trees in the Thyolo escarpments in southern Malawi has let to the drying of some trees which were a source of water for irrigation downstream. The study observed that the cutting down of trees in the mid-Shire has led to the increased soil erosion which has affected the hydro electricity generation and irrigation activities in the Lower Shire.

- The cutting down of trees has also led to the erosion of indigenous knowledge as far as knowledge of names and species and their functions is concerned. Indigenous trees have been replaced by exotic trees.

3 Policies that that govern biomass use

There are a number of policies that have bearing on biomass energy use in Malawi. The existing policies govern biomass use from different angles. The important policies include the National Energy Policy, Forestry Policy and the Biomass Energy Strategy.

[4] These are ceremonies which mark entry into adulthood in a society.

3.1 The National Energy Policy, 2003

The energy sector is aimed at achieving the following long term strategic goals:

1. Make the energy sector sufficiently robust and efficient to support GoM's socioeconomic agenda of poverty reduction, sustainable economic development, and enhanced labour productivity;
2. catalyze the development of a more liberalised, private sector driven energy supply industry in which pricing would reflect the competition and efficiency that would have developed through the reformed process; and
3. transform the country's energy economy from the one that is overly dependent on biomass (93%) to one with high modern energy component to its energy mix. A biomass commercial mix target of 50%-50% is set for 2020.

The objectives of the energy policy include: improving efficiency and effectiveness of the commercial energy supply industries; improving the security and reliability of energy supply systems; increasing access to affordable and modern energy services; stimulating economic development and rural transformation for poverty reduction; improving energy sector governance; and mitigating environmental, safety, and health impacts of energy production and utilisation.

3.2 The Forestry Policy, 1996

Forestry policy is concerned with production of wood resources in man-made plantations, woodlots, and natural woodlands. The policy provides a framework for sustainable production and conservation of wood resources and recognises the importance of wood fuels in the national energy supply and the need to bring about improvements in their sustainable production and supply. The policy specifically mentions the woodfuel needs of farmers in its general objectives and strategies, and recognises the importance of forest products in improving the quality of life in rural communities and providing a stable local economy. Additionally, the policy calls for a reduction in the dependence on woodfuel as a source of energy through switching to alternative sources of fuel and adopting woodfuel-saving devices so that 50% of energy should be sourced from non-biomass sources.

3.3 The Malawi Biomass Energy Strategy, 2009

The overall objective of the Biomass Energy Strategy is to ensure a sustainable supply of affordable woodfuels. Its three specific objectives are to:

i. Increase the supply of sustainable woodfuels;
ii. increase the efficiency of energy use; and
iii. create the institutional capacity to manage the biomass energy sector.

3.4 Other policies affecting the governance of biomass use and supply

There are other policies that have indirect bearings on biomass energy use and demand in Malawi. One of such is the Land Policy, 2000 which defines use of each piece of land in Malawi and this has a bearing on biomass production. Malawi's Land Policy of 2000 aims at providing title deeds to owners of customary land (half of Malawi's forest land is designated customary land). It is envisaged that such a move will encourage holders to make investments such as developing woodlots. However, this has not been enacted.

The Malawi Growth and Development Strategy (MGDS) which is the current development agenda also hinges on biomass production and use. One of the themes of the MGDS is sustainable economic growth, which covers the conservation of natural resources such as fisheries, forestry and the environment. This has a bearing on the future supply of biomass.

3.5 Stakeholder analysis of biomass energy in Malawi

A number of institutions define the biomass sector in Malawi. These include those that regulate production and use of biomass energy, those that produce biomass energy, and those that produce alternative sources of energy. There are also other organisations that are not directly involved with the use of biomass but their involvement is on advocacy. These include Forestry Governance Learning Group (FGLG).

Table 5: Stakeholder analysis of the biomass energy sector in Malawi

Name of stakeholder	Category	Summary role	Potential role in ESPA Project
Malawi Energy Regulatory Authority	Public sector	Regulating energy use including biomass in Malawi	Rationalize the regulations regarding use of biomass energy in Malawi
Department of Energy	Public sector	Regulating energy use including biomass in Malawi	
Department of Environmental Affairs	Public sector	Ecosystem accounting	Include ESPA activities in the national systems
Forestry Research Institute of Malawi (FRIM)	Public sector	Conducting research on species which can produce biomass efficiently	Identify species that are efficient producers of biomass
Malawi Industrial Research and Technology Development	Public sector	Development of technology	Development of technology that is efficient in biomass use as a source of energy.
GTZ/EU	Donor community	Coordinating donor activities in the energy sector	Supporting evidence based decision making through support of research in the biomass energy sector
Forest Governance Learning Group and other NGOs	NGOs and CSO	Promote the efficient production and sustainable utilization of biomass as a source of energy	Involved in the identification of efficient production systems
Academic institutions (University of Malawi and Mzuzu University)	CSO	Carrying out research in the production and sustainable use of biomass energy resources and conducting socioeconomic studies	
Estates (tobacco and tea)	Private sector	Producing biomass for energy production and where there is a shortfall purchase biomass for energy production	Involved in the production and development of the biomass market value chain
Smallholder farmers	Private	Production and consumption of biomass for energy production	Involved in the production and development of the biomass market value chain
Small and medium biomass entrepreneurs	Private sector	Producers, processors, transporters, wholesalers and retailers of biomass	Involved in the production and development of the biomass market value chain
Community actors	CSO	Control of income generating activities and community resource control	Forming groups implementing sustainable biomass energy production and efficient utilization
ESCOM	Private sector	Producing alternative sources of energy to biomass energy	None
Petroleum Importers Limited	Private sector	Set price for petroleum products therefore affect households' access to petroleum product which are alternatives to biomass	None
ILLOVO Sugar Company	Private sector	Producer of ethanol which is a biomass energy source	None
Wood Processors (WICO, RAIPLY etc)	Private sector	Processors of wood into wood products	Provision and marketing of biomass fuel from leftovers

The Malawi Energy Regulatory Authority (MERA) and the Department of Energy are responsible for regulating energy use including biomass in Malawi. The Department of Energy is also responsible with facilitation of the implementation of the Energy Policy. Producers of biomass energy include small holder farmers, tobacco estates, and forest reserve owners. Other private companies such as ILLOVO which produce ethanol as a by-product of sugar production are also considered as biomass energy producers.

There are a number of institutions that produce or supply alternative energy sources and thus have a bearing on biomass energy. The main actor in this category is the Electricity Supply Corporation of Malawi (ESCOM) which is responsible with generation, transmission and distribution of hydroelectric power. Others include the Petroleum Pricing Commission (PCC) which was a government agency with the responsibility of buying petroleum products on behalf of petroleum companies. This was replaced by Petroleum Importers Limited (PIL). In recent months and during same time last year, there was fuel shortage in the country because of the company's inability to purchase enough fuel on time.

Lastly, the general public has a large bearing on biomass use since most of this is used by them although these are not heavily involved in decisions regarding planning of biomass use and supply. There are also some companies that make use of wood and their by-products are used as source of energy for cooking in the households. These include the Wood Industry Corporation of Malawi (WICO) and RAIPLY. The industry, transport and service sectors also have important bearing.

4 Innovative projects in biomass use

In response to decreasing stock of biomass, a few innovations have been put in place during the years. These are in form of products and or business Model.

4.1 The Blantyre fuelwood project

This was a peri-urban fuelwood project in southern Malawi which started its operation in 1986. During the first fifteen years there was direct government involvement in the production, transportation and marketing of fuelwood, which had as its main objective the supplying of affordable fuelwood to the urban poor. The Malawi Government decided to hand over the management of the project to indigenous rural communities. Partly because the original project had been implemented in a top-down approach that had generally alienated these communities, this transfer of management was beset with problems. Furthermore, the underlying economics of the project were problematical, which called the supposed benefits to these rural communities into question. The institutional framework being put in place, and the involvement of the rural communities in the management of the planted and indigenous woods at this late stage, while well intentioned and perhaps the best option available, still showed vestiges of the top-down approach. The project became unsustainable and was unlikely to succeed without continued donor support. The project is still in existence in some areas but a closer scrutiny would offer good insights of the do and the don'ts.

4.2 Gelfuel in Malawi

D & S Gelfuel Company marketed gelfuel in Malawi for a short period in the late 1990s to the early 2000s. It was being promoted in urban areas to encourage household to reduce reliance on charcoal. However the main problem the company was facing was that the landed price of the inputs was so high that the product could not compete with substitutes. They tried to lobby government to remove duty so that the product could compete favourably but eventually, the company stopped the project on this account.

Figure 8: Gelfuel burner and fuel container

Fuel and the burner

The gelfuel is smokeless, odourless, not poisonous, easy to handle and to store and can be used in traditional cooking stoves. Moreover, it reduces carbon dioxide emissions by up to 50% compared to wood and diminishes pressures on forests. To produce gelfuel, denatured ethanol from sugar or starch crops is mixed with a thickening agent (cellulose) and water through a very simple technical process, resulting in a combustible gel. The gelfuel is thus renewable and can be locally produced in most countries in Africa.

4.3 Improved Forestry Management for Sustainable Livelihoods (IFMSL)

The European Union has been implementing a project named Improved Forest Management for Sustainable Livelihood in which areas living near forest reserves have been supported with some livelihood activities so they should diversify away from exploiting trees in the reserves. We have not been able to access any evaluation report yet. However, areas next to forest reserves such as those in Machinga and Zomba continue experiencing deforestation.

4.4 Biodiesel projects

There are a few biodiesel projects being undertaken in Malawi. During this study two such projects were reviewed as follows:

4.4.1 JANEEMO project

This is an innovative new enterprise based on ethical biofuels and their by-products being conducted by Climate Futures for at least three years. The name, JANEEMO is an acronym of the three species that the project is supporting. These are Jatropha, Neem and Moringa. Farmers are encouraged to grow these on marginal lands and as living fences around households and fields.

These species have oil-rich seeds that can be processed to produce locally used biofuels for lamps, stoves and generators, or turned into soap. Additionally, the residue from this process can be used to produce biogas for cooking and then finally as an agricultural fertiliser. In addition, extracts from the Neem and Moringa trees have important nutritional as well as medicinal uses.

Climate Futures helped develop the programme's strategy, business plan and carbon finance. It was also commission a film and educational materials for Scottish school children. The innovativeness of the project is through carbon financing the communities have been able to produce biomass from which they have generated income as well as non-income nonetheless important benefits for their households as well as communities.

4.4.2 The Jatropha project

TNT, WFP and local Malawian partner BERL (Bio energy Resources Ltd) are building a sustainable Jatropha business in Malawi that will give local smallholder farmers a new cash crop to grow and harvest that will create a reliable source of income.

Jatropha is a tree which can grow on waste land unfit for agriculture, and therefore is no danger to food production. Jatropha can also control the erosion of cultivated land and absorb CO2 from the air. The nuts from the Jatropha tree can be used to make various biological products. The seedcake can be used as organic fertilizer and in combination with the nutshells, it can be used as a replacement for firewood. The nuts themselves contain crude oil which can be used for lighting, cooking or engine fuel in rural areas. The crude oil can further be processed into glycerine (which can be used to make candles, soap, and cosmetics), and, most importantly, into biological fuels.

The growing of Jatropha therefore enables a number of objectives to be achieved. The alleviation of poverty and protection from food shortages is achieved by growing and selling the Jatropha nuts, farmers' income levels will improve in a more sustainable way, providing food security. At the same time the growing of Jatropha creates an additional income for farmers, and the replacement of fossil-fuel import with bio-energy production. On the environmental front, the trees has positive effects on the environment as it produces 'green' fuels, compensates for CO2 emissions and prevents deforestation. The persistent energy crisis in Malawi will be alleviated as Jatropha produces sources of energy (e.g. candles and firewood).

By 2010, 25,000 smallholder farmers had planted 6 million Jatropha trees in the project. The operational proof of concept has been established at the start of 2010. A full scale production plant is under construction.

Just as the JANEEMO Project, the Jatropha project is able to meet biomass energy needs together with other benefits through carbon reduction projects. These projects can easily be replicated in the country as long as northern institutions are willing to support these initiatives.

5 Conclusions formulated as a theory of change for biomass energy use in-country

In this paper, we have reviewed the status of biomass energy supply and utilisation in Malawi as well as the policies and programmes that are linked to biomass energy use and supply. Most of the information presented in the paper is from published and unpublished documents.

The review shows that biomass is the main source of energy for the majority of the population in Malawi. Currently, the total demand for biomass energy is estimated at 8.92 million total wood equivalent (t.w.e.) or about 13.38 million cubic metres solid wood (or 24.3 million cubic metres of wood stacked). Although the poor are the main users of biomass energy in Malawi, it is clear that almost all households use biomass as a source of energy. Among the high income households, biomass energy is used together with other forms of energy such as electricity, paraffin and LPG while poor households mostly use biomass energy. Biomass is therefore an important energy source for poor households. Between rural and urban areas, it has been shown that biomass energy is more important in rural areas than in urban areas such that almost all the energy consumed in the rural areas is from biomass.

Firewood and charcoal are the most common biomass energy sources and these are obtained from products from different forest and land tenure arrangements, which include government forest plantations and forest reserves, private forest plantations and indigenous wood (customary land). Currently, it is estimated that the annual sustainable supply of all biomass is some 2.7 times the demand. However, the seemingly surplus biomass energy is not accessible to all parts of the country because of spatial distribution of biomass resources. There are large surpluses in northern Malawi, but these are neither economically nor physically accessible to the bulk of the population living in the centre and the south because of high transportation costs. Therefore any efforts to improve production of biomass as a source of energy in the country should concentrate in the central and southern Malawi where there is more pressure than in the northern region. At the same time, programmes addressing biomass energy in the northern region should concentrate on sustainable use of the existing resources.

Biomass makes significant contributions to the national economy but this is underestimated in official statistics. The value of charcoal produced in Malawi is estimated at US$57 million while firewood is estimated at US$117.2 million. Overall, it is estimated that forestry sector's contribution to the country's GDP is 6.1%. At household level, biomass has been an important means of livelihood to many Malawians for a long time. The forestry sector employs a lot of people additional to those in the informal sector, and those involved in fuel wood supply chain. Apart from offering employment, biomass is also a source of income for many people at different stages of the value chain.

The National Energy Policy, Forestry Policy and the Biomass Energy Strategy are the three major policy documents that regulate biomass utilisation and production in Malawi. There are also a number of institutions that define the biomass sector in Malawi. These include those that

regulate production and use of biomass energy, those that produce biomass energy, and those that produce alternative sources of energy. There are also other organisations that are not directly involved with the use of biomass but their involvement is on advocacy, providing regulatory framework, and training and research. In general the policies and projects have aimed at reducing pressure on existing biomass energy resources through promotion of utilisation alternative energy sources, promotion of alternative livelihood sources, and prudent management of existing biomass resources.

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