Climate Change Mitigation in Africa

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Part 2: Presented Papers

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PART 2: PRESENTED PAPERS

Botswana Country Study

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1 Overall project Framework

This study was carried out in Botswana, Tanzania and Zambia as part of the Southern African Greenhouse Gas (GHG) Mitigation exercise and was funded by the Danish International Development Agency (Danida). The project was conducted parallel to the UNEP/GEF project which involved 8 other developing- countries and 2 regional projects in Latin America and the SADC region.

In Botswana, the Danida project focused primarily on the Energy Sector.

2 Objectives of Project

The project analysed the baseline economic, energy development and greenhouse gas (GHG) scenarios, and abatement costing of plausible greenhouse gas mitigation options in the energy sector of Botswana.

The analysis period for both the baseline and mitigation scenarios is up to 2030 with the short term stretching from 1994 to 2005 and the long term up to 2030. The short-term economic projection was based on Botswana's 7th and 8th National Development Plans that span the periods between 1991-1996/97 and 1996/97-2002/03 respectively. The Long Term economic framework was based on the framework for Botswana's Vision 2016 (Botswana Vision 2016, 1996; 1997) with some modifications (stagnated) for the long term growth rates in the transport and commerce sectors. The sectoral growth patterns in the baseline by assuming the above sectoral growth rates are presented in Fig 1.

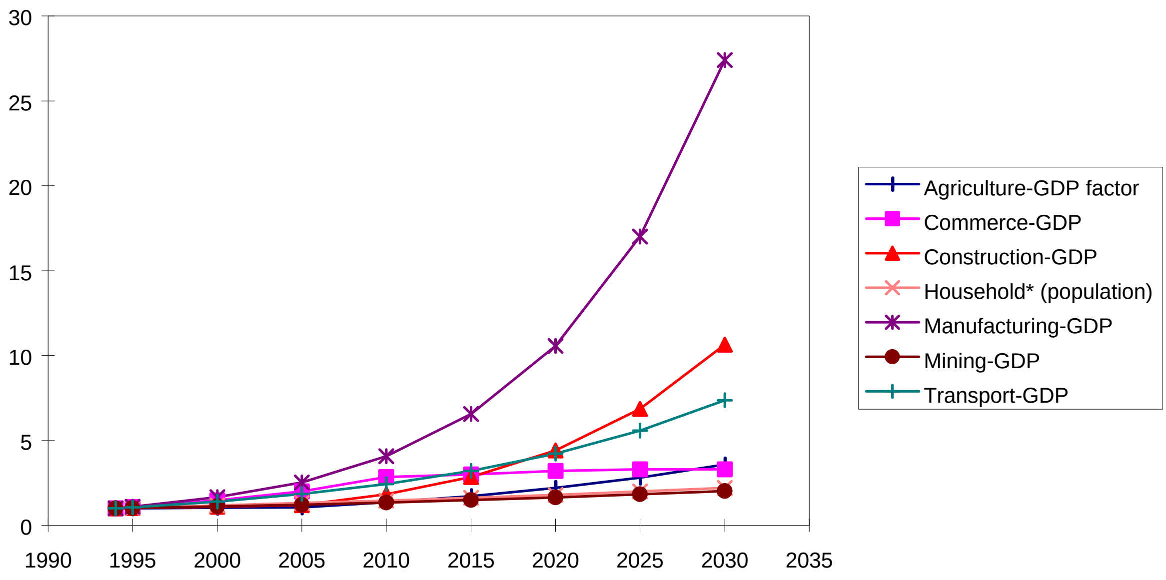

Fig 1 Baseline factorial sectoral economic (GDP) growth (LEAP output).
Factors are related to 1994/95 base year which has a factor of 1

The economic development as indicated by GDP was then linked to energy intensity in the future energy demand scenario and the related GHG emissions for the economic sectors.
The future domestic energy scenario for the domestic sector was calculated based on demographic projections derived by the Central Statistical Office (1996) of Botswana (Table 1).

Table 1 Projected de-facto national, urban and rural populations

	1991*	1994	2005	2030
Urban-towns	286 779	328 203	524 276	1 209 410
Urban villages & Rural villages	1 040 017	1 097 195	1 439 615	2 480 383
Total	1 326 796	1 425 398	1 963 891	3 689 793

**Census Year*

For the transformation or Power sector, the current power plants and the ones planned in the time horizon were considered in the baseline scenario.

3 Modelling

The modelling tools from which secondary socio-economic and energy data were derived are the Macro-Economic Model of Botswana (MEMBOT) and the Botswana Energy Master Plan (BEMP) respectively. The Long-Range Alternative Planning (LEAP) and the Greenhouse gas Abatement Costing Model (GACMO) were used in this study to create the baseline scenario and the abatement costing of mitigation options respectively.

The LEAP model was then used to produce the energy and GHG baseline scenarios for the time frame to 2005 and 2030 by assuming the autonomous energy efficiency improvements (AEEI) quoted in Table 2

Table.2 Assumed AEEI values for the various fuel technologies

Fuel	AEEI % per annum
Fuelwood	-0.5
coal	-0.5
paraffin/kerosene (domestic)	-0.5
other petroleum products	-1.0
solar	-1.0
Agriculture diesel	-0.5
All electricity devices	-1.0

4 Fuel Demand

The result from the LEAP analysis show that fuelwood is the dominant fuel throughout the time horizon with contribution shares of 43% in 2005 and 31% in 2030.

Gasoline is the second largest fuel in demand in 2005 (21%) and 2030 (30%) but shows faster annual growth rates (4.4-4.7%) in demand than fuelwood (1.6% to 2%). The other important energy source/fuels in the total energy demand are diesel (13-17%), electricity (7-10%) and coal (9-12%) as shown in Fig.2. The other petroleum products consisting of aviation gas, kerosene/jetfuel, fuel oil, lubes and LPG together with solar are expected to contribute the remaining 3 to 4% to the total energy fuel/source demand in the future scenario.

Petroleum products generally will have the highest annual growth rates (>3.5%) in demand especially in the short term. All the fuel/source demand annual growth rates will decline in the long term except for coal, lubes, and diesel and aviation gas which show higher annual growth rates between 2005 and 2030.

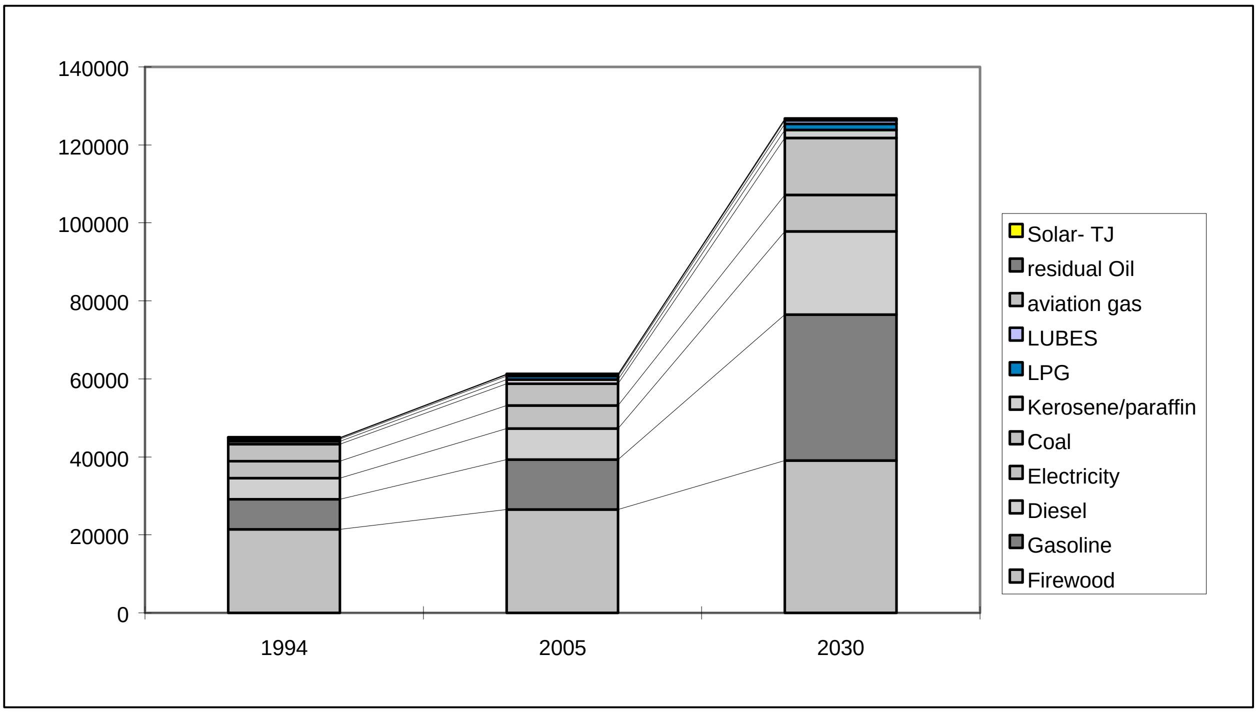

Fig.2 Projected Energy Fuel demand in the Baseline 1994-2030. (TJ)

The overall annual growth rates in total energy demand for the demand side are 2.9% in the short term and 3% in the long term.

Sectoral Energy Demand

Fig. 3 shows that up to 2005, the household sector will still be the largest consumer of energy in Botswana contributing 45% to the total energy demand. Transport (28%), Industry (16%) and Commerce (10%) are the next largest energy contributing sectors. Agriculture will contribute only 1% to the sectoral energy demand.

The household sector is however overtaken by the transport sector in 2030 (Fig 3.2.2) as the sector with the largest contribution to the energy demand with 42% share compared to fuelwood which will contribute 32%.

The transport sector energy demand is expected to grow 5 times between 1994 and 2030 while energy demand in all the other sectors will only increase by at most 3 times.

Transport and industry sectors show an increase in their shares in the long term while the household and commerce sectors shares are reduced. Agricultural energy share remains constant at 1% throughout the time horizon.

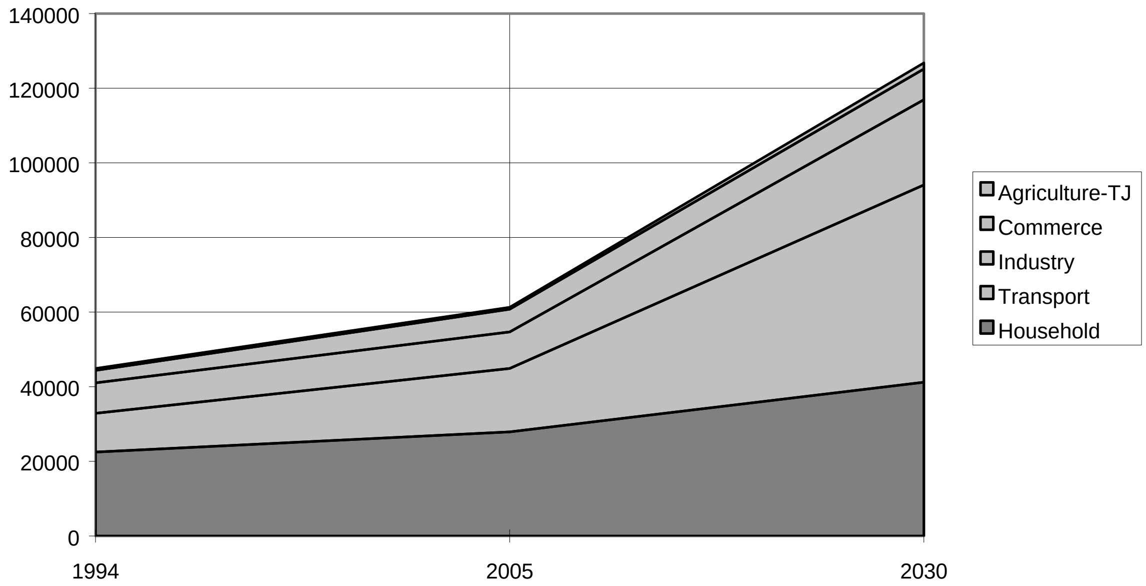

Fig 3 Projected Sectoral Energy demand in Baseline 1994-2030.

Energy Demand annual growth rates will be highest in the Commerce and Transport sectors in the short term with growth rates of 5.6% and 4.6% respectively. The other sectors have annual growth rates of 2% and below. Transport energy demand growth rate is consistent in the long term while that of Commerce declines to 1.2%. Energy demand annual growth rate of the agricultural and industrial sectors to 4.4% and 3.5 % respectively in the long term. The annual growth rate for the household sector declines in response to decline in the growth of fuelwood demand.

Major energy growth will occur in the transport sector because the sector responds to growth in all the other sectors. Energy demand in Industry will also be increasing in the long term due to expected rapid growth in manufacturing. The energy demand in Industry will significantly be reduced if the BCL mine closes, as the mine is the largest consumer of electricity and coal on the Demand Side in Botswana.

5 Transformation energy

Transformation Input Energy Demand by Fuel

Fig 4 shows the energy fuel/source demand in the transformation/power sector.

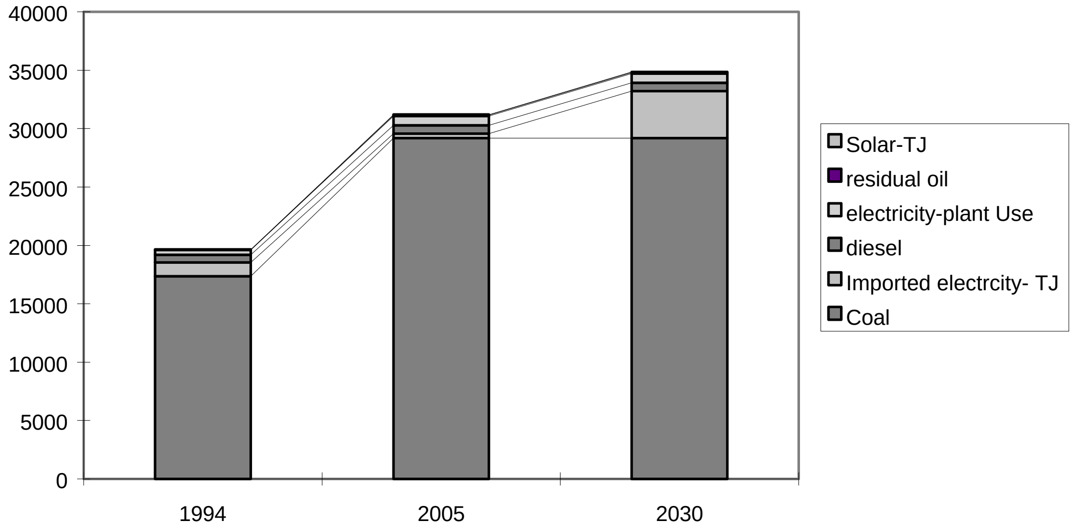

Fig 4 Projected fuel demand for electricity generation in Baseline (x1000 TJ) by Fuel

Coal will be the dominant fuel used in the power sector contributing 94% and 84% to the total transformation energy inputs in 2005 and 2030 respectively.

Actual coal demand however will stagnate after 2005 as power imports become increasingly important after 2005. The reduced power imports to 1.2% of total energy inputs in 2005 is a reflection of increased local generation capacity at Morupule of 120MW which is expected in 2003. Beyond 2005 imports are the second largest energy input contributing 12% to the total transformation input energy by 2030.

Electricity for plant use and diesel for diesel plants also do not increase after 2005 but together contribute 4 to 5% to the transformation energy input.

The highest annual growth rates in fuel demand will be registered in the short term except for imported power that will decline. Plant electricity demand, fuel oil and coal will have high growth rates of 6.1%, 5.5% and 4.8% respectively responding to the upgrade of local generation at Morupule Power Station. Diesel demand will increase slowly (1.1%) in the short term as a result of anticipated growth in demand for DEMS power.

In the long term growth rates of fuel/source demand are zero for all the energy sources/ fuels except for imported power and solar energy which grow at 9.9% and 2.8% respectively.

The proportion of imports increases in the long term to meet increasing electricity demand in the absence of additional local generation capacity.

Solar energy input will be increasing but will still be small to make a dent in the power sector.

Energy Demand by Power Plant

Fig 5 shows the transformation energy inputs for the power plants expected to be in operation in the study horizon.

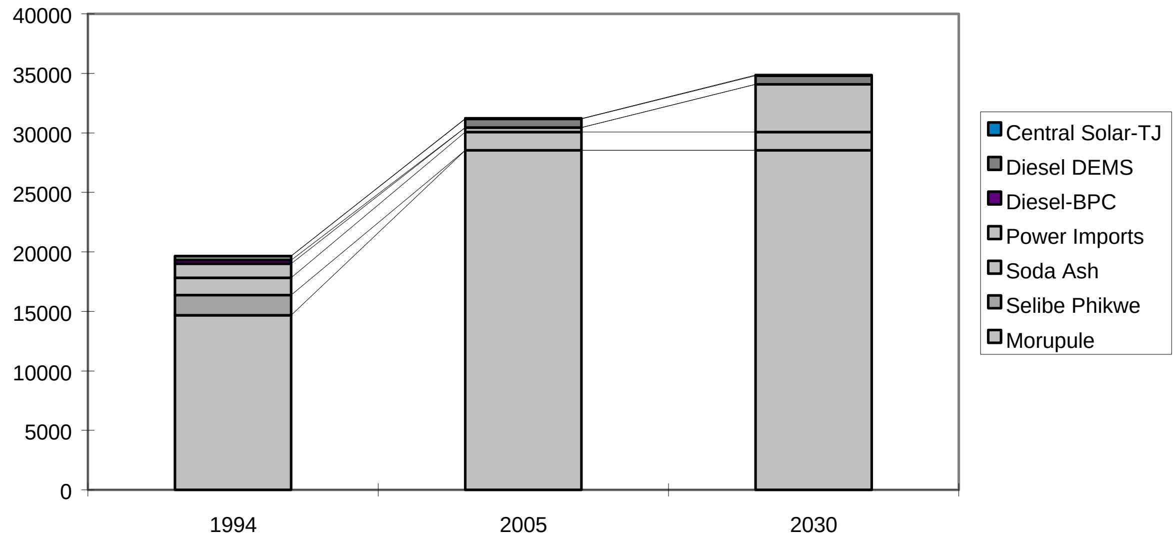

Fig 5 Projected Transformation input Energy Demand in the baseline by Power Plant (TJ)

Morupule Power Plant will be the main consumer of energy in the Power sector and also the largest local generation plant with a demand of 91% and 84% of the total transformation energy inputs in 2005 and 2030 respectively.

Botswana Soda Ash generation plant will have a constant capacity of 20MW throughout the time horizon hence the constant energy input demand. The plant energy demand share will be about 4 to 5% of the total transformation energy inputs throughout the time horizon.

Diesel plants operated by the Department of Electrical and Mechanical Services (DEMS) will have an energy demand share of about 2%. Diesel plants operated by the Botswana Power Corporation will be slowly phased out to be negligible in 2005.

Selibe Phikwe energy input demand is only reflected in 1994 since the plant was decommissioned in 1996 but had energy input share of 8.5% in 1994.

Whilst centralised solar plants are expected to steadily increase in capacity to about 5 MW by 2030, the solar energy input share in the power sector will still be negligible (0.1%).

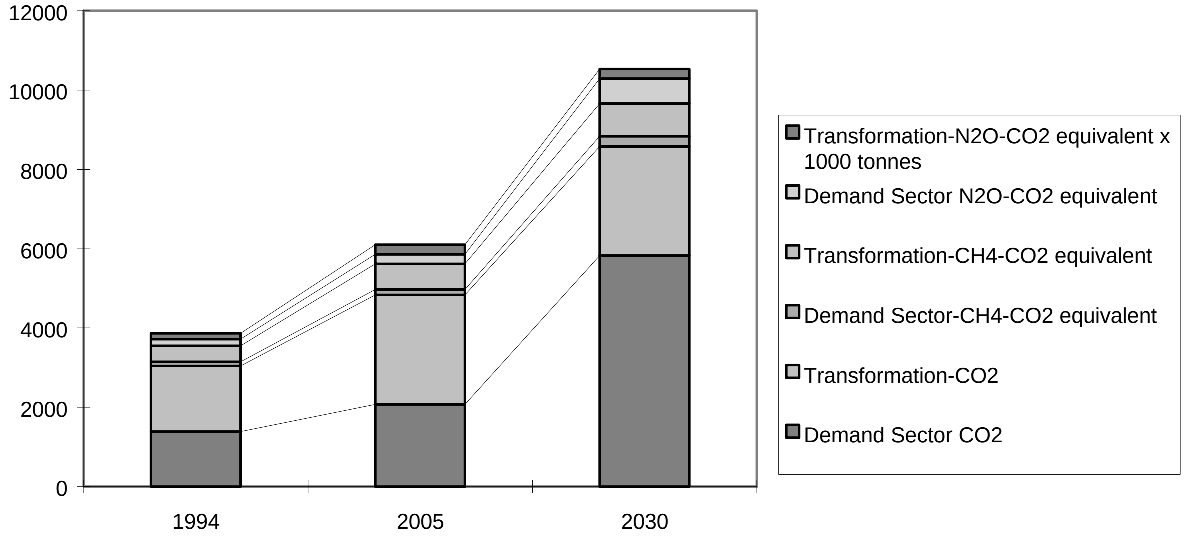

Fig. 6 Baseline GHG emissions by gas type expressed as CO_2 equivalent (Energy demand and supply sectors)

6 Baseline GHG Emissions

The total calculated CO_2 equivalent emissions in 2005 and 2030 were found to be 6100 Gg and 10530 Gg respectively compared to the base year (1994/95) emissions of 3860 Gg.

Demand and Transformation Side GHG Emissions

The supply side of the energy sector in Botswana will release more (60%) of CO_2 equivalent emissions (3648 Gg) compared to the demand sectors which will release 2452 Gg in 2005. On the individual gases, the transformation/power sector emits 57% of the CO_2, 83% of CH_4 and 50% of N_2O. The high CO_2 emissions will be due to the power generation which was also dominant in the base year. The high methane on the supply side is mainly due to coal mining.

In the long term (2030) the demand side becomes dominant emitting 64% of the total CO_2 equivalent emissions but its contribution of CH_4 remain less (24%) than that of the supply-side. The demand side will also emit about 72% of the N_2O emissions in 2030. The high CO_2 and N_2O emissions will result from the high petroleum products demand particularly gasoline/petrol and diesel in the transport sector. Fig 6 shows the GHG growth pattern in the baseline.

The combination of high petroleum products and coal demand in industry will exceed coal for transformation which will not increase after 2005 hence the higher CO_2 emissions for the demand side. Petroleum products also have a higher N_2O coefficient than coal.

The distribution of CO_2 equivalent emissions in the baseline would suggest placing mitigation emphasis on the transformation in the short term and on the demand-sectors in the long term. The selection of mitigation options however depends on the available opportunities in the sectors.

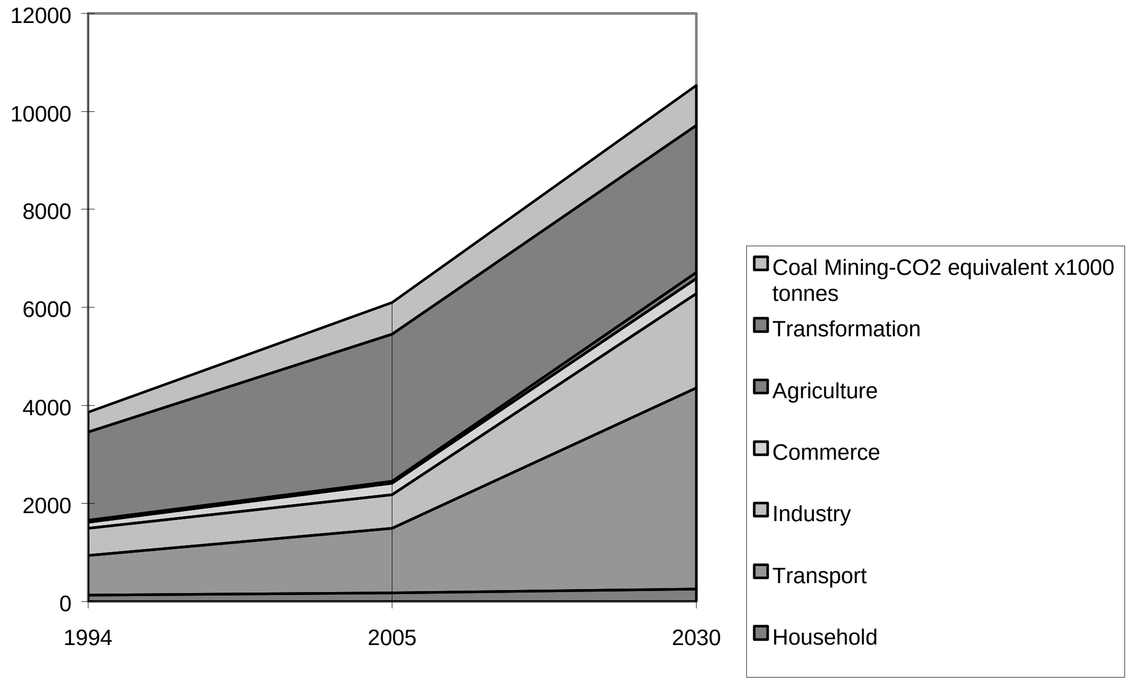

Fig 7 CO_2 equivalent Emissions by activity/sector type

Sectoral GHG Emissions

In the short term, power generation/transformation sector excluding emissions from coal mining will be responsible for 49% of the total CO_2 equivalent emissions (6100Gg) followed by the transport sectors with 22%. This is not surprising, as these are the sectors consuming most of the fossil fuels namely coal, petrol and diesel respectively. Coal mining will emit CH_4 emissions equivalent to 11% of the total CO_2 equivalent emissions.

Industry and commerce will contribute 11% and 4% to the total CO_2 equivalent emissions respectively. The household and the agricultural sector will contribute the remaining 3%.

In the long term, the transport sector becomes the largest CO_2 emitter with 39% of the total CO_2 equivalent emissions (10530 Gg) followed by power generation with 29% of the emissions. Industry and coal mining will contribute 18% and 8% to the emissions respectively. The rest of the emissions will be emitted by commerce (3%), Household (2%) and agriculture (1%).

Fig 7 shows the anticipated CO_2 equivalent emissions growth pattern by sector. The sectoral emission distribution would suggest aiming to reduce GHG emissions from the transport, power generation and industry sectors.

7 Selection of Mitigation Options

A portfolio of mitigation options was identified for the energy sector and GACMO was used to calculate the abatement costs and the potential GHG reduction of these selected mitigation options. In the analysis it was ensured that the penetration rate of each option was a proportion of the total penetration capacity in the baseline produced by LEAP.

Table 3 Plausible Mitigation Options for Botswana's Energy Sector

MITIGATION OPTIONS	PENETRATION 2005	PENETRATION 2030
Supply Options		
1. Power Imports-hydro		
2. Reforestation- eucalyptus	200MW	300MW
Central Solar PV Plant	9810 ha	9810ha
Landfill gas for power	2MW	49MW
	69000 tons waste (1.8MW)	169000 t waste (4.5MW)
Biogas home plant	13000 plants	21000 plants
Demand Options		
<u>Household sector</u>		
1.Prepaid meters	35000 meters	136 000 meters
2.Efficient Lighting- CFLs	810000 light points	1820000 light points
3.Geyser Timer	56000 timers	145000 timers
4. solar geysers	1000 geysers	2400 geysers
5.Solar PV home systems	25000 SHS	39000 SHS
<u>Industry</u>		
Boiler Efficiency	20 boilers	50 boilers
Motor Efficiency	30000kW	56000 kW
Power Factor Correction	31 MVAR (200MW)	31MVAR (200MW)
<u>Transport</u>		
Pipeline for petroleum products	190767 toe	1095903 toe
Electrified Railway line	2200 kit	4640 kit
road freight to rail	3700 kit	7700 kit
Gasoline to diesel switch	12800Petr; 8660 diesel TJ	37400 ,22100TJ
vehicle inspection	22760TJ fuel km- 18409505 v-km	62060TJ
paved roads		18409505 v-km
<u>Agriculture</u>		
Conservative tillage	100000 ha	100000 ha
Solar PV pump	7300 boreholes	5100 boreholes

The mitigation options presented here are for both energy supply and energy demand sectors. Selection of the options analysed also considered data availability and the importance of the options to Botswana's economy. Table 3 summarises the selected options and their penetration rates used in the analysis of each option.

The cost of GHG reduction/ton and total reduction potential for each option were sequenced in a cost curve. The cost curve coupled with Botswana's development priorities and macro-economic impacts of applying the options formed the basis for suggesting the country's mitigation strategy.

8 Implementation Aspects

Analysis of implementation aspects for the mitigation options was based on the following parameters:-

- Institutional capacity
- Difficulty in organising and the lead time required
- Transaction costs not included in the cost analysis which could be a hindrance
- Short and long term effects and sustainability
- Government position or policy on the subject

9 Macroeconomic Impact Assessment Criteria

Each mitigation option was analysed for macro-economic impact based on the following criteria:

- Impact on balance of payments
- Revenue collection e.g. in form of taxes
- Employment loss or creation
- savings on energy consumption and avoided fuel import- bills or deferred investments
- Improvement in economic efficiency/competitiveness
- Cross-sectoral linkages
- Improvement in health aspects
- Improvement of social standards
- and
- Land rehabilitation.

10 Mitigation Strategy for Botswana

Cost Curve Analysis

The cost curve is one way of presenting a climate change mitigation strategy for a country. It is a graph showing a possible sequencing of mitigation actions based on their costs of implementation. The cost curve logically suggests that options with the lowest cost are implemented first rising to the expensive ones.

Table 4 shows nine (9) mitigation options which can be implemented at negative costs out of the twenty-one (21) total options analysed. These relate to both electricity and diesel energy savings. The majority of the options in the household electricity savings have negative costs so these can easily be effected with the limited financial resources available in the households.

Those related to diesel savings are mostly in the transport sector. The cost of diesel savings in the transport sector also depends on the intensity of use. The higher the intensity of use e.g. in terms of t-km carried or toe transported, the lower the costs of reduction. Hence the cost of mitigation actions in the transport responds to economies of scale. Notable changes are in the option involving the pipeline and shifting from diesel to electric locomotives. In the case of the pipeline, the cost shifts from positive cost in 2005 to negative cost in 2030 when the fuel demand has increased to warrant the pipeline. The cost of diesel-electric locomotives drops to less than half that of 2005 in the same period as the freight size increases.

All the renewable mitigation options involving both solar and biogas have positive costs due to the currently high costs of equipment purchase. Reforestation programme also has a positive cost due to high water demand for plants in Botswana as a result of the high temperatures.

In terms of GHG reduction potential, the intensity of use or penetration rate and the unit potential are obviously the determining factors. The pattern in the results however shows that in the household sector, a significant GHG reduction can be realised by limiting the geyser/electric water heater consumption. In the transport sector, pavement of roads and introducing vehicle inspection could result in significant avoided GHG emissions. The expensive options in the transport sector however have relatively low potential for reducing GHG emissions. Substitution of coal based electricity with hydropower or landfill gas based electricity has significantly avoided GHG emissions on the supply side.

The combined effect of all the mitigation options is depicted in Fig. 8 for the short term (2005) and Fig 9 for the long term (2030).

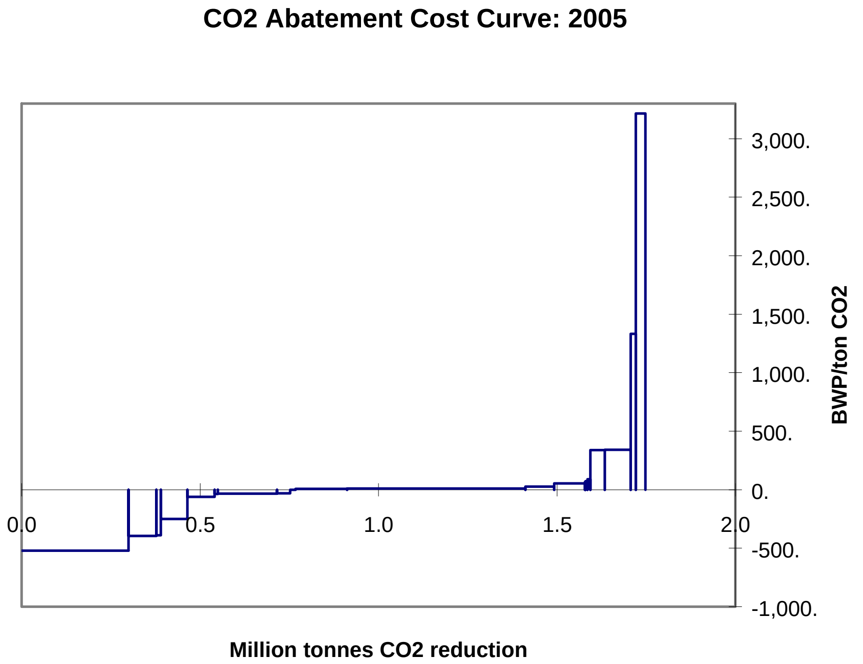

Fig 8 Cost curve for energy system GHG abatement options 2005

Table 4 GHG mitigation in the energy sector of Botswana and their costs or reduction and reduction potentials in 2005 and 2030

	Mitigation option	Cost of GHG redn. BWP/ton	Unit Size	Driver	Fuel used	CO_2 Equiv. tons/unit	Penetration rate 2005	cum reduction Mt/yr. 2005	Penetration rate 2005	cum reduction Mt/yr. 2005
1	*paved roads	-521.3	1	route	petrol/diesel	299814.7	1	0.30	1	0.30
2	Road freight to rail	-395.2	1	ktsystem	diesel	77781.7	1	0.38	1	0.46
3	*Tillage	-388.5	1	tractors	diesel	27.0	463	0.39	463	0.47
4	*Efficient lighting	-249.2	1000	bulb	coal	92.4	810	0.47	1820	0.64
5	*Prepayment meters	-61.6	1	meter	el-coal	2.2	35000	0.54	136000	0.93
6	*Efficient boilers?	-36.6	1	boiler	coal	476.8	20	0.55	50	0.96
7	*Geyser time switches	-34.7	1	timer switch	el-coal	3.0	56000	0.72	145000	1.39
8	*Power factor correction	-30.5	1	MVAR	el-coal	941.5	39	0.75	39	1.43
9	Hydropower Imports	-10.3	1	kW	el-coal	10	120000	+1.2	120	+1.2
9	*Fuel pricing	0.0	1	fuel system	petrol	15237.0	1	0.77	1	1.44
10	*Biogas from landfills	6.7	1	t-waste	el-coal	2.1	69000	0.91	169000	1.79
11	Vehicle Inspection	8.7 (3.1)	1	fuel system	petrol/diesel	183115.6	1	1.41	1	1.98
12	*Efficient motors	26.6	1	kW	el-coal	2.7	30000	1.49	56000	2.13
13	*Biogas for rural households	54.9	1	digester	wood	6.6	13000	1.58	21000	2.27
14	*solar home systems	63.9	1	system	paraffin	0.08	25000	1.58	39000	2.27
15	*Solar geysers	72.8	1	geyser	el-coal	5.0	1000	1.59	2400	2.28
16	Central PV electricity	90.1	1	MW	el-coal	4386.7	2	1.59	50	2.50
17	*Solar PV water pumps	338.3	1	pump	diesel	5.5	7300	1.63	5100	2.53
18	*Reafforestation	342.1	1	9810 ha	sinl	72086.67	1	1.71	1	2.60
19	*pipeline	1333.1 (-212.7)	1	pipeline	diesel	15624.2356	1	1.72	1	2.69
20	diesel to electric rail	3216.3 (1406.8)	1	t-km system	diesel	27040.8	1	1.75	1	2.75
	TOTAL-baseline							6.1		10.53
	GHG Reduction %	exclude	hydro	imports	option			28.7%		26.1%

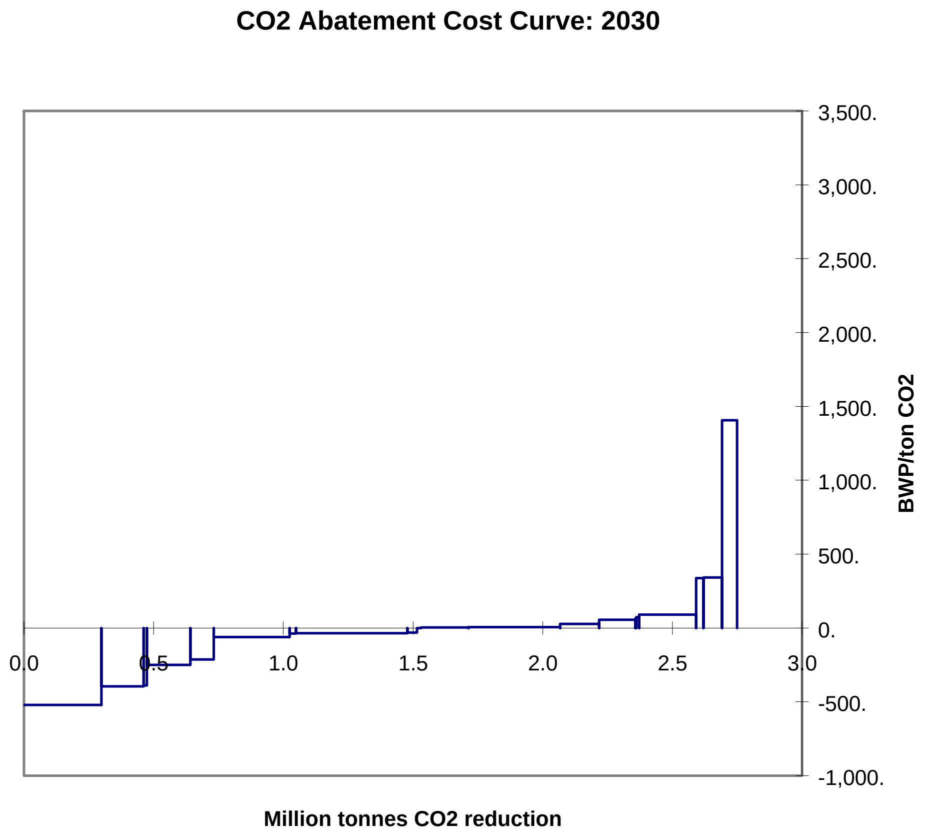

Fig 9 Cost curve for energy systems GHG abatement options 2030 (Excludes the guaranteed hydropower imports of 1.2mt at p-10.3/ton)

Even if some of the options have small contributions, the overall GHG reduction of these mitigation options is significant at 28.7% of the total energy sector emissions in 2005 and 26.1% of the emissions in 2030.

Guaranteed hydropower as a mitigation option for Botswana taken in place of the expected expanded capacity in Botswana could alone reduce 1.2 million tons. This option has however not been included in the cost curve as arguments suggest that the option could be more of a regional mitigation option than a national one. The interest should however not be lost to explore how Botswana could benefit from this option.

Sensitivity test with discount rates involved increasing the rate from 6% to 10% and reducing it to 3%. The higher discount rate of 10% resulted in higher costs of reduction but none of the options shifted from negative costs to positive costs. The option of substituting coal power with hydropower was the closest one to shifting in that direction.
Similarly, reducing the discount rate to 3% reduced the costs of mitigation but again none of the options changed sign.

If the cost curve were to be the basis of mitigation strategy in Botswana, then Botswana would initially mop up the opportunities in the household sector which have negative costs and low capital layout followed by the ones with negative costs in the transport sector and power sector since the capital layout is relatively higher. Both the renewables and the expensive transport options would probably be implemented in the long term when it becomes cost-effective to use them.

11 National Development Priorities and Realignment of Mitigation Options

A meaningful climate change mitigation strategy in developing countries has to follow the development aspirations of those countries and in this respect, the strategy must take cognisance of the national development policies and possible impacts on the macro economy.

The aspects evaluated in this section included government policy on the mitigation measure/option, easy of implementability and the macroeconomic impacts consisting of impact on Balance of Payments, employment creation, social benefits like health aspects improvements or income generation, economic efficiency or competitiveness in business, environment enhancement. Consideration was also given where the option accrues benefits in another sector e.g. in form of deferred investments in additional power plants or enhancing agricultural output.

Table 5 is an attempt to rank the analysed mitigation options by considering these aspects. No weights have been allocated to these factors as these are not known but national governments could decide their weighting in the formulation of the GHG Mitigation strategy.
In this simple approach, only the total number of positive (+) impacts for each mitigation option determined the ranking factor.

Table 5 Ranking of Mitigation Options by national development priorities

No.	Mitigation Option	Cost or GHG Reduction (BWP/ton)	Govt. Policy	Implement ability	Impact of balance of payments	employment	social benefits	economic efficiency/ competitiveness	benefits more than one sector	Local environmental enhancement	Ranking
1	paved roads	-521.3	+	+	-/+	+	+	+	+		6
2	Road freight to rail	-395.2	?	?	_/+	_	?	?	?	+	2
3	Tillage	-388.5	?		+	_	?	+	?	+	3
4	Efficient lighting	-249.2	+	++	_	0	+	+	+	+	7
5	Prepayment meters	-61.6	++	++	_	0	+	+	+	+	8
6	Efficient boilers	-49.2	?	+	_	?	+	+	+	+	5
7	Geyser time-switches	-34.7	?	+	-	?	+	+	+	+	5
8	Power factor correction	-21.9	+	+	- -	?	?	+	+	+	5
9	Hydro power	-10.3	?/+	?	- -	- -	+	+	+	+	4
10	Fuel pricing	0.0	?	++	0	0	- -	?	0	?	2
11	Landfill- gas for Power generation	6.7	?	+	_	+ +	+	+	+	+	7
12	Vehicle Inspection	8.7 (3.18)	++	+	_	+	++	+	+	+	9
13	Efficient motors	26.6	+	+	_ _	?	?	+	+	+	5
14	Biogas for rural households	54.9	?	+	0	+	++	?	+	+	6
15	solar home systems	63.9	++	++	_ _	+	++	?	?	+	8
16	Solar geysers	72.8	+	?	_	?	?	+	+	+	4
17	Central PV electricity	90.1	?	?	_ _	+	?	?	?	+	2
18	Solar PV water pumps	338.3	+	-	- -	-	+	+	+	+	5
19	Reforestation	342.1	+	-	0	+	+	?	+	+	5
20	pipeline	1333.2 (-212.7)	?	?	_ _	+	?	?	+	?	2
21	diesel to electric rail	3216.3 (1406.8)	?	?	_ _	+	?	+	-	?	2

- = not in favour; + in favour (-- or ++ means more so); ? not known/clear; 0= none

By this type of analysis, the sequencing of the climate change mitigation options in Botswana's strategy could resemble the ranking in Table 6.

Table 6 Realignment of GHG Mitigation Options based on national development interests

Ranking No.	GHG Mitigation Description	Cost of Reduction BWP/ton
1	Vehicle Inspection	8.7 (3.18)
2	Prepayment meters	-61.6
	Solar Home systems	63.9
3	Efficient lighting	-249.2
	Landfill gas for power generation	6.7
4	Paved roads	-521.3
	Biogas for rural households	54.9
5	Efficient boilers	-36.6
	Geyser time switches	-34.9
	Power factor correction	-30.5
	Efficient motors	26.6
	Solar PV pumps	338.3
	Reforestation	342.1
6	Hydropower guaranteed imports	-10.3
	Solar geysers- Water heaters	72.8
7	Zero tillage in agriculture	-388.5
8	Road to rail freight	-395.2
	Fuel switch from petrol to diesel through differential pricing	0.0
	Central PV plants	90.1
	Pipeline for petroleum products	1333.2(-212.7)
	Electrifying the railway line	3216.3 (1406.8)

This type of ranking would be satisfactory for zero or negative cost options but the sequence of implementation could be altered where large capital layouts are required for implementation. This may be the case with solar PV pumps that even if government were willing to promote solar technologies, would be slowed down by the cost of the technology. Similarly with reforestation whose cost is higher compared even to solar PV pumps.

Some of the options ranked low could be implemented earlier if the appropriate policies can be put in place e.g. zero tillage in agriculture.

The recommendation is that the mitigation strategy be reviewed from time to time for any necessary amendments.

12 Conclusions and Recommendations

Conclusions

There is a relatively significant potential to reduce GHG emissions in the energy system of Botswana by applying a number of mitigation options. The potential in by applying a set of

21 mitigation options analysed in this study was found to be about 28.7% in 2005 and 26.1% in 2030 as in Table 7

Table 7 GHG emission levels in the baseline and mitigation scenarios

	2005 CO_2 equiv. Emissions	2030 CO_2 equiv. emissions
Baseline scenario	6100	10530
Mitigation scenario	1750*	2750*
Reduction %	28.7%	26.1%

** This reduction excludes a potential reduction of hydropower of 1.2 MT*

More GHG reduction could be achieved through additional options that may avail themselves in due course.

With respect to the present analysis, about 51% of the reduced emission could be achieved by implementing zero or negative cost options. The situation may change when more options are added.

Recommendations

Projects to assess in detail the best conditions under which the mitigation measures could be implemented should be the first follow-up activity.

Appropriate government policies directed at implementation of these measures will be necessary. The options should always have some national development benefits but guidance and incentives will be imperative to ensure involvement of the various actors in the economy.

An example of such incentive is practised in South Africa by ESKOM where awards are given annually to consumers of electricity and the suppliers of equipment. The awards are for outstanding achievements in energy efficiency measures or supply of efficient equipment. This is in form of money (up to R 20 million) and trophies but other forms of incentives can be formulated. Successful examples elsewhere could also act as incentives as local actors may also be driven by the aspiration to achieve similar energy and costs savings.

The awareness campaign is a process which takes time for results to be realised. It is therefore recommended that this aspect with respect to energy and cost savings be initiated soon for Botswana's actors to move towards sustainable development. A dedicated institution for energy efficiency and conservation could be the starting point for implementing of GHG mitigation.

In order to have a continued perspective of the mitigation objective, repeated mitigation analysis and refinements of costs probably including some transaction costs need to be made.

Mauritius Country Study

D.D. Manraj, Central Statistical Office, Mauritius

1 General background

The Republic of Mauritius consists of a main island, Mauritius and a group of small islands scattered in the South West Indian Ocean. The island lies within the tropical belt and enjoys a tropical maritime climate. It is dominated by mountainous peaks and surrounded by coral reefs.

The total land area of the Republic is 2,040 km^2 and has a Marine Exclusive Economic Zone of 2,000,000 km2. In 1995, the population was estimated at 1,142,513 and the country ranks high in population density with 560 people per km^2. Nearly half of the population lives in the urban areas. Life expectancy at birth is 66 years for males, 74 years for females. The adult literacy rate is 82%.

2 Economy

Mauritius is a very small island with no natural resources and is heavily dependent on international trade. Over the last 25 years, Mauritius has sustained an average growth rate of 5.6%. It has undergone major structural changes from an agricultural monocrop economy with rapidly growing population, high unemployment rate and low per capita income to a more diversified economic structure driven by four main pillars: sugar, manufacturing, tourism and financial services. GNP per capita in 1995 stood at US$ 3,424.

Mauritius has come a long way and is being quoted in many fora as an emerging Newly Industrialising Country. It was recently ranked first in the 1998 African Competitiveness Report followed by Tunisia and Botswana.

3 Energy

Mauritius has no known oil, gas or coal reserves but is only endowed with limited renewable energy resources namely hydropower and bagasse. Bagasse represents about one third of the country’s energy requirements and meets almost all of the sugar industries energy demand.

4 Mauritian National Climate Committee (NCC)

Mauritius signed the UN Framework Convention on Climate Change at the Earth Summit in Rio de Janeiro in June 1992 and was the first country to ratify it in September 1992.

The National Climate Committee (NCC) is a multi-sectoral organisation, established in June 1991 under the chairmanship of the Prime Minister’s office and with the Meteorological Service as Co-chairman.

The Committee comprises representatives of the following organisations:

- Department of Environment

- Meteorological Services
- Central Statistical Office
- State Trading Corporation
- Marine Authority
- Ministry of Energy
- Ministry of Economic Development and Regional Co-operation
- Ministry of Health
- Ministry of Agriculture and Natural Resources (Forest Department)
- Representatives of Private Sectors
- National Transport Authority

The Meteorological Office has taken the lead in this project and has constituted 3 technical working groups namely Energy and Transport, Agriculture and Economy comprising statisticians, economists, engineers and researchers.

5 Inventory of Greenhouse Gas Emissions

The major sources and sinks of Greenhouse gas emissions identified are

- Energy
- Industrial processes
- Solvent
- Agriculture
- Land use change and forestry
- Waste

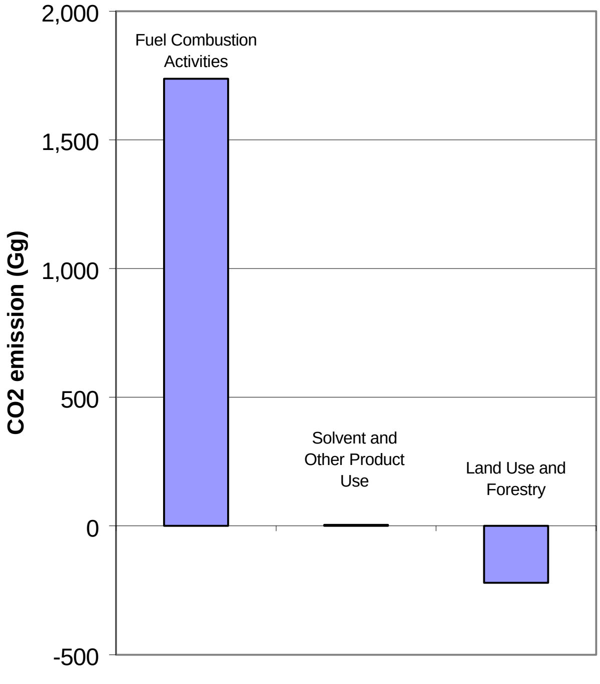

Figure 1. CO_2 emissions and sinks (Gg), 1995

In 1995, 94% of the GHG emission comprised carbon dioxide and the main sources of emissions were:

Transport	38%
Power	37%
Manufacturing	16%
Other	9%

Table 1. National emissions of all gases, 1995 (Gg)

CO_2	1736.8
Other gases	111.6
CO	67.0
NMVOC	15.7
SO_2	13.4
CH_4	4.6
N_2O	0.7
NO_x	10.2

6 Projections of GHG Emissions up to 2020

We have worked out our GHG emissions up to 2020 under the Business as Usual scenario. How did we get the inputs for the Business as Usual Scenario and for the Mitigation and No Regrets policy options that are being presently discussed. We are lucky in a sense that the groundwork had already started way back in 1990 under the National Long Term Perspective Study and which was finally published in 1995. These reports depict the long-term vision of Mauritius, the projections, the choices and the alternative policy options.

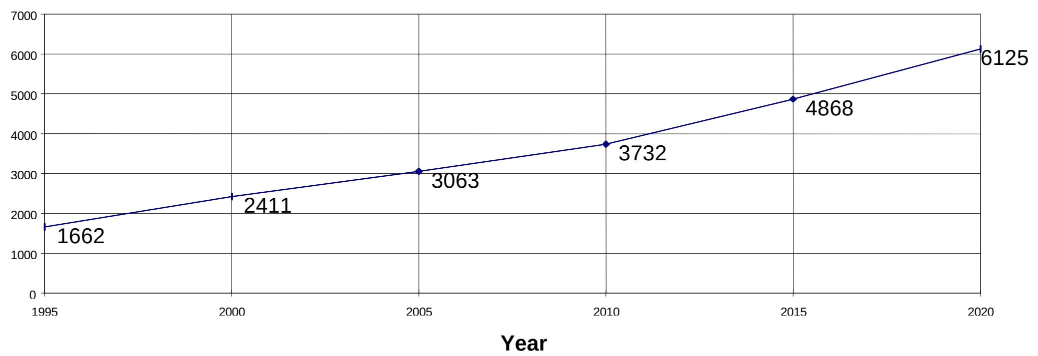

Figure 2. Emission of CO_2 (Gg) 1995-2020

7 No Regrets Policy- Transport Sector

The following mitigation options are now being considered in the "No Regrets Policy" scenario in the transportation sector.

- Trip reduction and increase in vehicle occupancy
- Improving fuel efficiency
- Enhanced traffic management
- Improving freight transport energy efficiency

Mitigation and Adaptation scenarios to curb CO_2 emissions are still being worked out and it has not been possible to produce the relevant cost curves for this regional workshop. However, rough estimate shows that reduction of CO_2 can be achieved only by making use of No Regrets measures and could be of the order of 5% and 8%.

8 Mitigation Options

Projects identified for mitigation options are:

- Energy Sector - Renewable Sources (Solar, Wind, Biomass)
- Transport Sector - Fuel switching & Mass transit transport
- Manufacturing Sector - Increase efficiency of energy use in the manufacturing process

The above projects have been singled out for a study of indirect costs associated with mitigation options. Prof. A. Markandya of the Bath University, UK will assist the Mauritian team. They include employment benefits/costs, secondary environmental benefits, income distribution and poverty impacts.

The work on the mitigation options will be finalised in mid June 1998 and the relevant cost curves will be included in our final report.

Zambia Country Study

Professor Francis D. Yamba, Centre for Energy, Environment and Engineering Zambia Limited (CEEEZ), Lusaka, Zambia

The study on “Methodological Development, National Mitigation Analysis and Institutional Capacity Building in Zambia” considers the following five common elements:

- Comprehensive evaluation of national social and economic development framework for climate change.
- Baseline scenario(s) projection(s)
- Mitigation scenario(s) projection(s)
- macroeconomic assessment
- Implementation Issues

Under evaluation of national social trends, social conditions related to employment and health were considered. In the employment sector, as a result of the liberalisation policy put in place by Government, there was a decline in the number of employment opportunities between the years 1990 and 1995. In the health sector, between 1990 and 1995, the Government introduced Public Health Reform Programme aimed at improving the delivery of services.

Under demographic trends with specific reference to population, population was estimated at 8.2 million by 1994. The study considered various factors affecting population growth in Zambia and adopted an average growth rate of 3%. With this growth rate, the total population is expected to reach 13.2 million by the year 2010 and 24.0 million by the year 2030.

Other areas considered under this category include major land use activities. The three major land use categories in Zambia are cropland, forest reserves and national parks. Forest reserves and national parks cover about 10% and 8% of the country, respectively, and are managed by the Forest Department and the National Parks and Wildlife Services.

The major uses of forests in Zambia are agriculture, woodfuel and timber harvesting. Out of a total land area of 753,000 km^2, land potentially available for agriculture is 420,174 km^2, which is 55.8% of total land area. However, land area suitable for crop production is 250,000 km^2, which is 33% of the total land area. While land currently utilised for crop production ranges between 110,000 to 150,000 km^2 constituting between 15 to 20% of the total land area cover.

Main national economic development trends included basic statistics on GDP structure and overall sectoral performance. The Zambian economy is categorised by mining, manufacturing industry, agriculture and transport. Copper mining and it’s export contributed 8% and 7% to GDP in 1990 and 1991 respectively. Despite this increase, efforts and measures have been put in place by Government to resuscitate the mining industry. Manufacturing sector experienced a decline in GDP performance between 1990 and 1995 as a result of liberalisation policies put in place by Government and the relatively shorter time available for existing companies in the country to adjust. However, the sector’s performance is likely to improve as a result of Government policy on privatisation of parastatal companies, since the new owners of such companies will endeavour to put more investments in their operations.

Agriculture plays an important role in the GDP structure in Zambia like other sectors, agriculture has also passed through turbulent times resulting in fluctuation of GDP between the years 1990 and 1995. To stop this decline the Government has put in measures particularly the Agricultural Sector Investment Programme (ASIP) aimed at improving the performance of the sector.

One of the main objectives of the study was to develop baseline scenarios in energy and forestry sectors. The main elements considered under baseline scenarios in the energy sector were energy demand and CO_2 emissions projections. To determine these parameters, the following assumptions were taken into consideration: population and household energy; household energy mix; economic activities measured in GDP; energy intensity; energy policy and; fuel prices. Together with these assumptions, energy demand and CO_2 emissions projections were calculated using the Long-Range Energy Alternatives Planning (LEAP) system. Another model used in the study is the Greenhouse Gas Abatement Costing Model (GACMO) which was specifically used to determine the cost of implementation of mitigation options on an individual basis.

Mitigation analysis in the energy sector considered five economic sectors namely: households; mining; industry; transport and; government service. The mitigation options considered in the household sector included energy substitution and efficiency of cooking appliances. In the industrial sector, the options of partial replacement of coal, diesel and fuel based boilers with electric were considered. Under transport and government/service, use ethanol-gasoline blend in petrol-propelled motor vehicles and improved maintenance of motor vehicles options respectively, were considered.

The total energy demand under the baseline is expected to increase from 198.29 million GJ to 322.61 million GJ by 2010 and 653.11 million GJ by 2030. Under mitigation, the increase is expected to rise from 198.29 million GJ in 1995 to 297.07 million GJ by 2010 and 579.23 million GJ by 2030 thereby giving a reduction of 7.9% and 11.3% in 2010 and 2030 respectively.

Under baseline scenario, CO_2 emissions from all the sectors considered increased from 17.02 million tonnes in 1995 to 26.45 and 48.47 million tonnes for the years 2010 and 2030 respectively. Whereas under mitigation scenario, CO_2 emissions increased from 17.02 million tonnes in 1995 to only 23.69 and 40.93 million tonnes for the years 2010 and 2030 respectively, giving a reduction of 2.8 million tonnes in 2010 and 7.86 million tonnes in 2030.

Using the GACMO, individual reduction and cost assessment of all mitigation options identified were analysed. It is evident from the results obtaining that most of the options in the Zambian scenario have negative costs putting Zambia in well placed position to positively contribute to abatement of CO_2 emissions through implementation of relatively lower cost options.

Baseline development in the forestry sector, considered the following scenario assumptions: forest land clearing for commercial firewood; cutting natural wood for timber harvesting, forest land clearing for charcoal production and forest land clearing for shifting and permanent agriculture. Mitigation options considered to reduce the resulting deforestation included maintaining existing stocks and expanding carbon sinks. With the help of the Comprehensive Mitigation Analysis Process (COMAP), biomass (carbon stock) and biomass supply and demand for the years 1990, 2010 and 2030 were determined. Also determined was the cost of saving of one tonne of CO_2 and investment cost per hectare. Under baseline scenario, results indicate that there is decline in forest land area between the years 1995 and

2030 as a result of ensuring deforestation. However, with implementation of the considered mitigation options, the trend is reversed with a positive increase in biomass pool.

The macroeconomic impact assessments of the projects recommended for implementation was undertaken as part of sustainable development and greenhouse gas limitation strategies for Zambia.

The macroeconomic assessment considered qualitative assessment of macroeconomic impacts of considered mitigation options relating to employment, saving on consumption, health aspects, improvement of social conditions, foreign exchange savings, export, competitiveness and internal savings.

Lastly, but not least, implementation issues were also considered in the study relating to investment requirements of the identified options and also the barriers for implementation of these options.

Tanzania Country Study

GHG Mitigation in the Forest and Land-use Sectors in Tanzania

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1 Introduction

Tanzania came into existence in 1964 when Tanganyika and Zanzibar were united. She is an East African country situated between latitudes 1^{o}S and 12^{o}S, and longitudes 29^{o}E and 41^{o}E with an area of 942,784 km^2. About 61,495 km^2 of the area constitutes inland water- bodies (water resources) including parts of the three big East African lakes - Victoria, Tanganyika, and Nyasa (Malawi).

The economy of the country has significance in the mitigation analysis. This is because technological development and technology transfer occurs in the economic framework. Furthermore measures of success in technological development are obtained in the economic performance of a country. As for Tanzania's economic situation, since 1985, the government of has been implementing several major policy reforms and the Tanzania society is today significantly different from it was some ten years ago. Economic social and political freedom has been introduced and the private sector is growing rapidly.

An objective of this study is to analyse the role of the land use sectors of Tanzania (especially forestry) on mitigation of greenhouse gases. Specific emphasis is placed on the relationship between forestry and energy supply from biomass. This is a follow up study on an earlier effort which worked on mitigation options in the country without an in-depth analysis of the forestry and land use sectors.

2 Review of Previous Climate Change Studies in Tanzania

Various climate change studies have been undertaken in Tanzania. The major ones include a study on Sources and Sinks of Greenhouse Gases in Tanzania; Technological and Other Options for the Mitigation of Greenhouse Gases in Tanzania; and Assessment of Vulnerability and Adaptation to Climate Change Impacts in Tanzania. We review the first two due to their close linkages to this study.

2.1 Inventories of Greenhouse Gas Emission

The study on sources and sinks of greenhouse gases (GHG) was undertaken in 1993, with the objective of establishing an inventory of sources of emissions and removal by sinks of GHGs in Tanzania. The results of the study showed that carbon dioxide emissions from Tanzania in 1990 amounted to 55,208 Gg CO_2. Total emissions, evaluation with the Global Warming Potential Index (GWP) indicates that the emissions of CO_2 contributed 55% to potential warming due to the 1990 emissions, CH_4 provided 44%, and N_2O provided 1% (Figure 1).

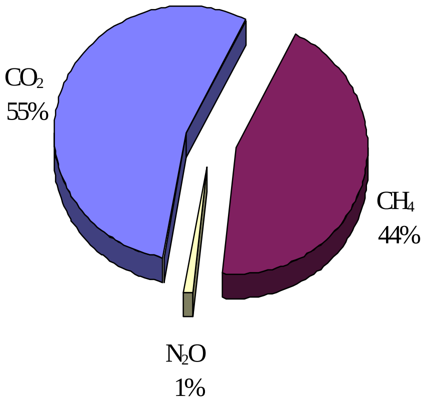

Figure 1: Important GHG Emissions in Tanzania

Land-use changes and forestry sector made the largest contribution (53%) towards the warming that may result from the 1990 emissions of trace gas in Tanzania. This was followed by agriculture (33%), energy (13%), and waste management (1%). Industrial processes contributed less than 1% of potential warming (Figure 2).

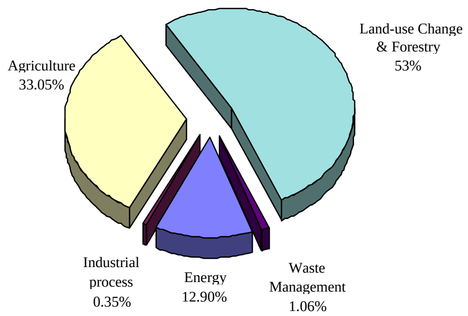

Figure 2: Sectoral contribution in GHG emissions

In general Tanzania's emissions are not significant compared to developed countries, but the results lead the country to design measures that will promote sound technologies for sustainable development goals. Table 2 shows a comparison of Tanzania's emissions with other countries.

Table 2: Comparison of Tanzania's GHG Emissions with World Emissions (Gg CO_2 Equivalent)

	Tanzania	Zimbabwe	South Africa	Mexico	Ukraine	Global
Energy	12,992	19,745	377,523	342,759	807,241	22,000,000
Industrial process	349	617	5,900	11,621	31,756	1,300,000
Agriculture	33,284	5,876	21,683	48,016	55,370	7,400,000
Land-use Change & Forestry	53,015	-142,312	3,240	116,882	-56,938	4,000,000
Waste Management	1,073	2,243	12,495	12,887	22,418	1,600,000
Total	100,713	-113,831	420,841	532,165	859,847	36,300,000

Source: (4)

2.2 Climate Change Mitigation

Sources of greenhouse gas emission analysed included energy, industrial, transport, forestry and land-use, agriculture and livestock, household, commercial, and informal sectors. A sectoral analysis was done and number of technological and non-technological options have been identified and will serve as input to various national plans and communication.

2.2.1 Sectoral Assessment

Identified mitigation options include, among others, the applications of efficiency technologies in energy production and use, efficiency in rice cultivation, better animal feed practices, efficient technologies for cement, pulp, and paper production, fuel switch in transport sector, transport management and optimisation in transport modes, afforestation, forest management, and urban tree planting.

2.2.2 Macroeconomic Analysis

The development of the long-term macroeconomic scenario was undertaken using a Cross Impact Matrix analysis. The Cross-Impact Matrix method starts by establishing a list of pertinent elements that make up the building blocks of the scenarios. These focus on the key interest relationships among those elements and methodically state whether that relation exists in each of the two directions between each possible pair of elements. The relation is expressed simply by the presence or absence (zero or one respectively) of any direct relationship between a pair of elements. As a result, a structural matrix is defined, representing the links between the systems key elements. A consistent combination of the different outcomes results in a definition of the different scenarios. Figure 3 shows the resultant scenarios.

In the analysis two major uncertainties for the long-term development scenarios were identified. These include external uncertainties concerning the evolution of export commodity prices, the foreign debt service, and external development support; and internal uncertainties including structural adjustment policies, provincial development strategies, land allocation policies, agricultural development priorities and the exploitation of abundant natural resources. The result of the Cross-Impact Matrix is consistent with the Tanzania’s Development Vision 2025 Targets.

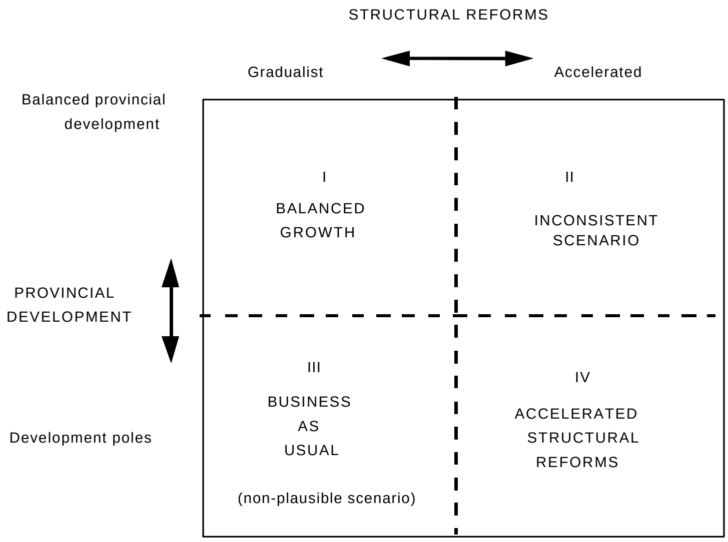

Fig. 3: The Structure of Tanzania's Development Scenario

The most likely scenario for the long-term development of Tanzania can be characterised by the predominance of structural reforms in the short-term, followed by a more balanced growth strategy in the long-term. Therefore a combination of the above scenarios results into a composite scenario.

2.2.3 Ranking of the Mitigation Options

A multiple criteria assessment method was used to rank the mitigation options. This was done with the help of Expert Choice software. Due to the relatively high number of options, they were evaluated against standards rather than against each other. Fig 4 shows the results of the ranking process.

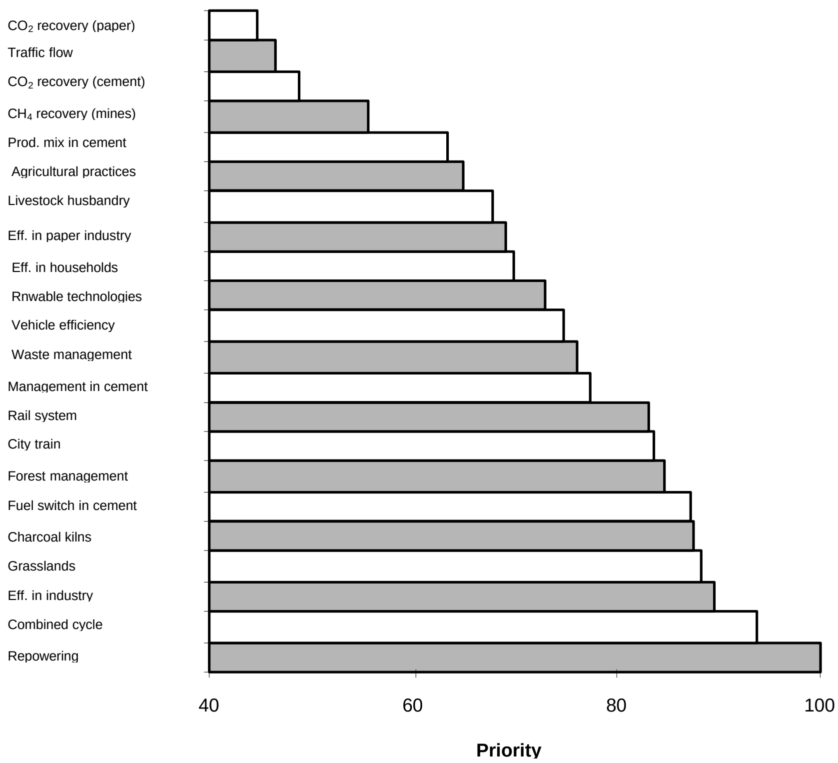

Fig. 4: Ranking of mitigation options

3 Methodology

Method adopted in this study involves the examination of the baseline and mitigation scenarios. Three scenarios are developed which include a “catastrophic” scenario whereby despite the existence of the policies and plans the sector takes a business as usual path and experience poor implementation of policies. The second scenario is the enhanced TFAP scenario in which the Tanzania Forestry Action Plan is implemented, but since its time horizon is up to the year 2008 it is projected to year 2020. The third scenario is the mitigation scenario that improves on the previous two scenarios by undertaking mitigation actions.

3.1 Deforestation and GHG Emission Process

Assuming that deforestation has three agents working at the same time, tree regrowth will not recover the original biomass in a short time, unless the area is left fallow for a long time. Furthermore, the activities are related, whereby logging removes the big trees and then charcoal making uses the remaining branches and agriculture clears the rest. Remains from agricultural clearing are either burnt on site or taken away as fuelwood. Other decay on site. Figure 5 illustrates the relationship between deforestation activities.

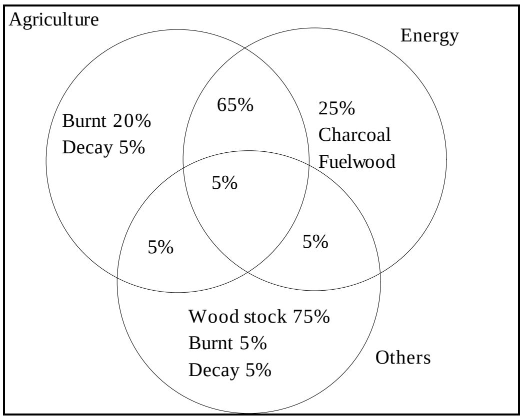

Figure 5 Deforestation Activities and Inherent Relationships

The existing policies and legislation have an implication in the current forestry status as well as to the success of any mitigation options. The relevant policies here include the land tenure and Land policy and legislation, forestry policy and legislation, environmental policy and legislation, population policy, and the national energy policy.

4 The Catastrophic Scenario

In greenhouse gas mitigation analysis, it has always been assumed that the baseline scenarios are consistent with national plans and programmes. However, in forest and land use sectors policies and programmes do exist, which forms the baseline, but due to various problems, they are not implemented. Therefore, in our analysis instead of having two path, the baseline situation and mitigation situation, there is a situation whereby the baseline path is not implemented. This path is hereby named the “catastrophic” scenario which is an inconsistent one and a business as usual trend is experienced. Under this scenario it is assumed that programmes in the forestry and land use sectors envisaged in the relevant policies are not implemented or are implemented in pieces. This may be due to various problems encountering the country including the following:-

- lack of financial resources to implement the programmes;
- lack of awareness on the part of stakeholders;
- incompatibility of other sector policies and programmes which relate to forestry and land use;
- less priority accorded by policy makers;

4.1 Characteristics of the Catastrophic Scenario

The catastrophic scenario assumes that the current deforestation rates persist and very little is done to redress the situation. Unsustainable harnessing of natural resources continues due to poverty and population pressure, and very little is done to intervene. Although literature put deforestation at between 300 to 749 kha per annum we use adjusted figures for the GHG emission used in the inventory. The adjustment were necessary because if such figures are used there will be no tree left in the country by the year 2000. We adjust for factors such as accessibility of the forests, whereby forests that are very far from the road are left untouched due to transportation problems. Therefore deforestation is limited to areas accessible by roads and railways, and areas which are close to settlements.

The following assumptions are therefore made:-

- Deforestation and emissions due to agriculture will continue to be influenced by population pressure and therefore its growth will be 2.8%;
- Deforestation and associated emissions due to other economic activities like timber and poles will be influenced by economic growth and therefore will grow at 5%;
- Inaccessible forests continues to operate the closed carbon cycle and therefore are not considered here; and
- CO_2 emissions and sequestration is therefore associated with dynamic activities of tree cutting/harvesting and regrowth/planting.

Forests that are accessible to human activities will suffer severely under the catastrophic scenario. Therefore, the tropical closed forests and mangrove forests that in most cases in Tanzania are located within reach of neighbouring inhabitant are in a danger of being depleted. The miombo woodland has an advantage of a big part of it being inaccessible. Figure 6 shows the behaviour of the forestry sector under this scenario.

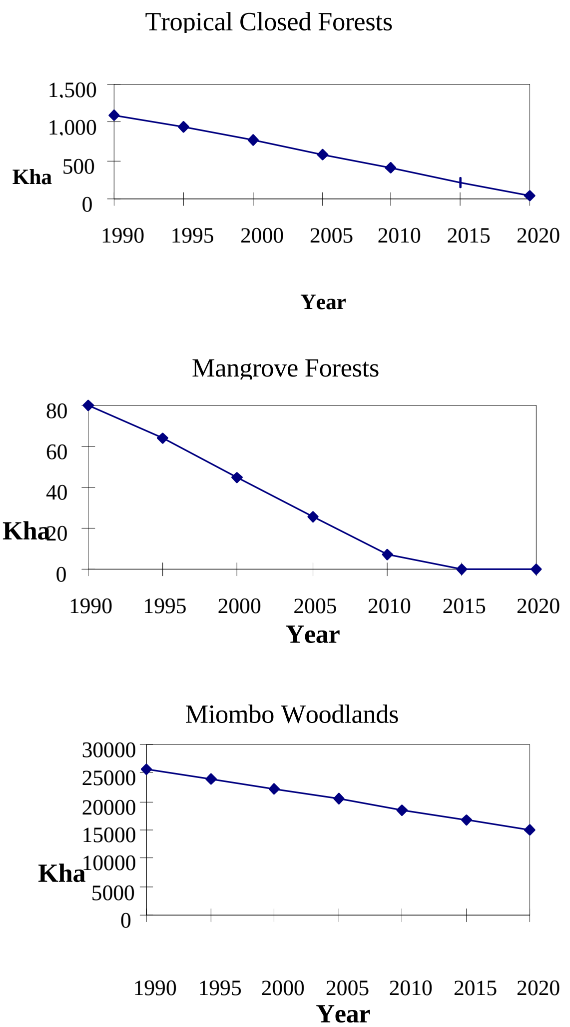

Figure 6 Deforestation trend for the catastrophic scenario

4.2 Greenhouse Gas Emissions under the Catastrophic Scenario

Due to unsustainable nature of development in this scenario, an increasing trend of GHG emissions from land use and forestry is experienced. Furthermore, the sinks are depleted hence diminishing uptake from the accessible forests and plantations.

Normally CO_2 emission from fuelwood consumption is accounted for in the forest sector during clearing of the trees. Other gases are accounted for in the energy sector. However, in this case emission from fuelwood is accounted for in the energy sector and specifically the energy use in the household and commercial sectors. Table 6.1 shows CO_2 emissions under the catastrophic scenario.

Under the catastrophic scenario net CO_2 emissions almost trebles, mainly due to extensive land clearing for agriculture and unsustainable harvesting of forests, which shrinks the sinks to less than one fifth. The situation is expected to worsen due to the fact that out of every 20 hectares of forests that are clearfelled only one hectare is planted.

5 The ‘Enhanced TFAP’ Scenario

The enhanced TFAP scenario development is based on the existing national development plans including the Tanzania Forestry Action Plan (TFAP) and projections based on Forest Management Plans. Since TFAP target is the year 2008, implementation beyond the year 2008 is extrapolated on the basis of these programmes and projects.

5.1 Programmes and Projects under the Enhanced TFAP Scenario

Programmes and projects under the enhanced TFAP scenario can be grouped into four. These are the Land husbandry programme, Forest management Programme, Forest Industries programme and Bioenergy Programme.

5.1.1 Land Husbandry

Land husbandry involves all activities related to sustainable utilisation of the land for various uses. These include agroforestry, maintenance of catchment forests, and sustainable woodfuel harvesting. Under village forestry programmes activities include afforestation, agroforestry and community forest for fuelwood. The TFAP indicates that 8000ha. of forests for fuelwood will be planted in a period of 20 years in peri-urban areas of various cities in Tanzania on commercial basis. Using expert judgement it means 400 ha per year. This figure will be used to extrapolate the number of hectares covered to the year 2020.

5.1.2 Forest Industries

The TFAP target is to ensure solution to the above problems through the following:

- utilisation of wood resources with less waste;
- where applicable, substitution of hardwood by softwood;
- more emphasis to be given to utilisation of lesser-known hardwood species; and
- utilisation of surplus softwood through new investment in industry capacity.

5.1.3 Forest Management

Activities in forest management programmes include protection and rehabilitation of the existing forests, as well as controlling them in the form of sustainable harvesting. Projects under this programme include gazetting of new forest reserves, management of the miombo forests, hardwood plantation in closed broadleaf forests and management of plantation forests including the Sao hill softwood forest. This programme is expected to cost US$ 33.33 million.

5.1.4 Bioenergy

Woodfuel and other forms of biomass dominate the energy balance and account for approximately more than 90 % of the primary energy supply. On the other hand, commercial energy sources, i.e., petroleum and electricity, account for about 8% and 1% respectively of the primary energy used. Coal accounts for less than 1% of the energy used. Nevertheless, Tanzania has a number of other indigenous energy sources including; a considerable potential of hydropower, coal, natural gas, solar, and wind.

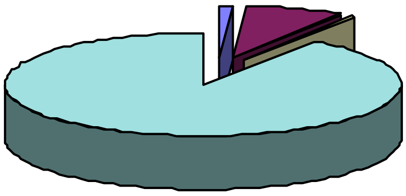

Figure 7: Energy Supply by Fuel (1995)

Strategies to achieve sustainable biomass energy supply include:-

- the increase of local wood supplies by various form of afforestation;
- reduction of wood energy needs through greater efficiencies of wood energy conversion and utilisation;
- substitution of woodfuels by alternative energy sources;

5.2 GHG Emissions from Enhanced TFAP Scenario

Estimation of greenhouse gas emissions resulting from the enhanced TFAP scenario has been made on the basis of illustration in Fig. 5, and the same assumptions as in the 'catastrophic' scenario. However, in the enhanced TFAP scenario it is further assumed that the proposed policies and programmes are implemented. It can be noted that some of the activities in the enhanced TFAP scenario are in themselves mitigation options. However, they will be magnified in the mitigation scenario.

In the greenhouse gas inventory the forest and land use sector combine the land use and the bioenergy activities in estimating carbon dioxide emission. Therefore in order to avoid double counting this system has been maintained. However, other gases have been analysed on the basis of devices to enable evaluation of the impact of technology in reducing the emissions.

Emissions in the land use changes assumes that the rate of increase of forest management activities and related tree growing activities will have the following effects:-

- increase sequestration at the same rate; and
- decrease of emissions from land use changes at the same rate.

6 The Mitigation Scenario

6.1 Identification of Mitigation Options in Forestry and Land-use

Identification of potential mitigation options involves the determination of relevant options, and methods for analysing the options. This involves data collection and review. This study makes a forest and land use sector analysis in respect of its development and associated greenhouse gases emissions.

The mitigation options have been divided into the supply side oriented options and the end use side options. Necessary measures to mitigate environmental deterioration through the forest protection and conservation option include:

i) introducing forest property rights, introducing bank credits of soft lending terms
ii) diversifying energy sources including rural electrification;
iii) encouraging the use of appropriate technologies;
iv) conserving biodiversity;
v) sharing of tangible benefits from the protected and conserved areas with surrounding population
vi) use of by-laws in controlling the cutting of wood, overgrazing, wildfire, and misuse of land;
vii) reserving 30% of all districts for forestry development;
viii) declaring all catchment areas to be forest reserves;
ix) promoting forestry extension services;
x) controlling the export of rare tree species;
xi) carrying out research and studies on forestry and biodiversity;

6.2 End-use Side Mitigation Options in Forestry

The end use side of the mitigation options includes the following:-

- Increased efficiency in product utilisation especially timber products;
- Increased efficiency in production and utilisation of bio-energy;
- Improved technologies in the end use devices (e.g., improved charcoal stoves);
- Substitution of wood derived products for renewable sources;
- Rural electrification; and
- Intensification and modernisation of agriculture.

In the mitigation scenario, due to sustainable management and use of forest resources it is expected that rate of deterioration of capacity of forests to sequester carbon will gradually diminish. This analysis did not consider the impact of intensification and mechanisation of agriculture, and therefore the status of clearing of forests for agriculture will remain as it is in the enhanced TFAP scenario. Figure 8 shows the comparison of the emissions from the three scenarios.

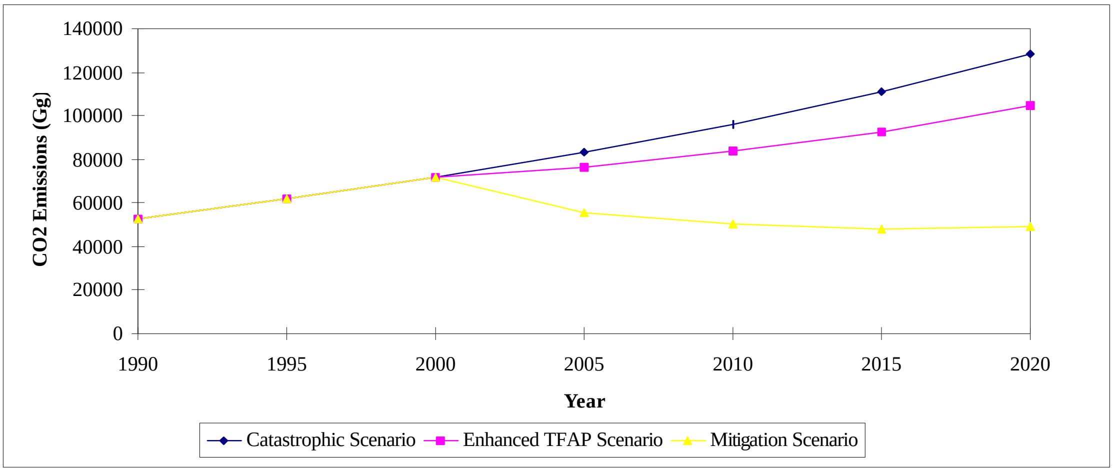

Figure 8: Comparison of CO_2 Emissions from the Three Scenarios

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Senegal Country Study (in French)

Evaluation des coûts de réduction des émissions de gaz à effet de serre au Sénégal

Ibrahima Sow
Coordonnateur National

Resume

Le projet UNEP/Risø « Economics of greenhouse gas limitation » a été exécuté par une équipe composée de la Direction de l'Environnement (Coordination), de la Direction de l'Energie et de la Direction de la Planification. L'équipe a été assistée au plan technique par notamment l'UCCEE/Risø, le LBNL (Lawrence Berkeley National Laboratory : CALIFORNIE - USA) et ENDA TIERS MONDE (Dakar).

Le cadre de référence pour l'étude est le plan national de développement socio économique (IX^{ème} plan). Toutes les informations relatives aux objectifs du projet et au choix des options étudiées ont fait l'objet de deux concertations (séminaires nationaux) ayant réuni les spécialistes aussi bien du public que du privé des différents secteurs concernés : Energie, Agriculture, Forêt, déchets, etc.

La première partie de l'étude a consisté à l'analyse du cadre de développement socio-économique du Sénégal, à l'établissement d'un bilan énergétique et à l'actualisation de l'inventaire des émissions de gaz à effet de serre (GES).
Le tableau suivant résume assez sommairement les données de base utilisées dans le développement des scénarios et du choix des secteurs ayant fait l'objet d'études de mesures d'atténuation.

Année	1995	
Données de base		
Superficie	196 722 km^2	
Population	8 133 000 habitants	
Densité	41 hab/km^2	
Taux de croissance démographique	2.7 %	
Population urbaine	39 %	
PIB (milliards F CFA*)	1 4 85	
PIB par habitant (F CFA)	279 456	
Taux de croissance du PIB	2 %	
Superficie cultivable (millions d'hectares)	3.80	
Superficie forestière (millions d'hectares)	11.66	
Répartition des émissions de GES	Gg Equivalent CO_2	%
Energie	3787	40.6
Industrie (Procédés industriels)	345.5	3.7
Agriculture	2958	31.7
Déchets	2226	24
Part du Sénégal dans les émissions mondiales	4 parts par 10 000	

1 $ US = 600 F CFA

Le développement et la projection des scénarios dans les différents secteurs de l'économie ont été effectués en utilisant le modèle LEAP (Long Range Energy Alternatives Planning). Sur la base des hypothèses conformes aux prévisions énergétiques et économiques du sénégal, deux types de scénarions ont été développés :

- un scénario de base :
- un scénario de mitigation.

Pour les deux scénarios, les secteurs suivants ont été retenus :

- Agriculture et Pêche ;
- Industrie ;
- Transport ;
- Ménages ;
- Administration.

Une distinction est faite entre Dakar comme centre urbain, les autres centres urbains et les zones rurales.

Enfin, les types d'énergie considérées sont :

- le bois ;
- le charbon de bois :
- le fuel ;
- le pétrole lampant ;
- le kérosène ;
- le GPL ;

- les résidus végétaux ;
- l'essence ;
- le diesel.

Dans le scénario de base , on suppose que le gouvernement ne met pas en œuvre de mesures spécifiques pour limiter les émissions de GES, compte tenu du fait que l'atténuation du changement climatique n'est pas une priorité absolue pour notre pays, comme pour la plupart des pays en développement. Néanmoins, les prévisions nationales et sectorielles sont prises en comptes dans ce scénario . Par exemple les taux de croissance appliqués sont des données officielles. Par ailleurs l'hydro-électricité est pris en compte à partir de 2003 pour les Barrages au niveau du fleuve Sénégal et 2007 pour celui du fleuve Gambie. Le bois et le charbon de bois continueront de dominer les consommations d'énergie des ménages.

Dans le scénario de mitigation les données officielles sont évidemment conservées ainsi que les projections concernant l'hydro-électricité. Cependant on considère une baisse de la consommation de bois , de charbon de bois et de pétrole lampant (kérosène). Ce choix est justifié par :

- l'utilisation de plus en plus importante de gaz naturel au niveau des centrales électriques grâce aux ressources existantes actuellement. En plus l'existence d'un gisement de 10 milliards de mètres cubes à une soixantaine kilomètres de Dakar a été récemment confirmé.
- La pénétration rapide de gaz butane GPL au détriment du bois et du charbon de bois
- Les autres paramètres sont restés constants.

Il en résulte une baisse de la consommation de bois et de charbon de bois du fait de la croissance rapide du gaz butane notamment. Les émissions, globales augmentent de 3% seulement par an entre 1995 et 2030 ; et à partir de 2020 les émissions de CO_2 dues à la biomasse commencent à diminuer.

Ces scénarios n'ont pas un objectif quantitatif dans le cadre de notre étude. Le but consistait tout simplement à montrer les tendances de demande énergétique des secteurs et les émissions de GES y relatives. Les possibilités d'atténuation quantitative sont étudiées dans l'analyse sectorielle des options de mitigation pour lesquelles des modèles ascendants ont été utilisés.

Concernant les options de mitigation proprement dites, (5) cinq études ont été réalisées. Ce sont :

1. l'étude sur l'accroissement des capacités de séquestration de carbone ;
2. l'étude sur l'intégration des énergies nouvelles et renouvelables dans la politique d'électrification ;
3. l'étude de l'amélioration de l'efficacité énergétique dans l'industrie;
4. l'étude sur la modernisation et la rationalisation du secteur des transports routiers ;
5. l'étude de la mise en place de décharges contrôlées avec récupération de méthane et compostage.

Cependant, il faut préciser que si l'analyse du cadre institutionnel et du cadre décisionnel pour faire face à l'évolution du climat ont fait l'objet d'un traitement satisfaisant pour l'ensemble des études, l'évaluation des coûts s'est heurtée dans les deux derniers cas à l'absence de données fiables ou tout simplement à l'ampleur des incertitudes en ce qui a trait notamment aux choix pertinents de techniques ou technologies appropriées et aux coûts économiques de réalisation d'une option donnée. En revanche, dans les trois premières études, les coûts des options par tonne de CO_2 évitée ou séquestrée ont été calculés .

Les résultats de ces trois dernières études peuvent être résumés comme suit

(I) Accroissement des capacités de séquestration de carbone

Les options étudiées consistent à des programmes de reboisement/rotation (500 hectares) et de protection forestière (199 875 hectares) dans la région de Tambacounda (Est du Sénégal) et de protection forestière (2 100 000 hectares) dans la région de Kolda (Sud du Sénégal).
Ces actions s'effectueront en relation avec des associations de villages et groupements bien organisés et identifiés au préalable en utilisant les outils de l'approche participative.

Les coûts additionnels par tonne de CO_2 séquestrée sont faibles (environ $ US 2) aussi bien pour l'option de « Afforestation/rotation » que pour celle de protection forestière dans la région de Tambacounda.

Ces coûts sont encore plus attractifs pour l'option de Tambacounda qui donne avec une moyenne négative autour de $ US 5.

(II) *Introduction des énergies renouvelables dans la politique d'électrification*

Quatre options ont étudiées dans cette partie : il s'agit de :
- l'Electrification décentralisée ;
- le Pompage pour hydraulique villageoise ;
- l'Electrification des infrastructures communautaires ;
- l'Electrification des infrastructures administratives ;

Le tableau suivant constitue une analyse comparative des différentes options

Secteur	Option d'atténuation	Coût standard de l'option d'atténuation (Fcfa/kwh)	Coût standard de la ressource évitée (Fcfa/kwh)	Emissions de CO_2 de l'option d'atténuation (kg de C/kwh)	Emissions de CO_2 de la ressource évitée (kg de C/kwh)	Coût net du carbone évité Fcfa/kg de carbone
Ménages	1- Electrification décentralisée	287	50	0,00	0,27	180
Tertiaire	2- Hydraulique villageoise	519	49	0,00	0,27	1737
	3- Infrastructures communautaires	208	55	0,00	0,27	566
Administratif	3- Infrastructures administratives	410	50	0,00	0,27	1333

Ces options , malgré leurs coûts relativement élevés constitue une bonne alternative pouvant conduire à une électrification rurale qui prend en compte la gestion de l'environnement dans un avenir proche.

(III) *Efficacité énergétique dans l'industrie*

Les études menées avaient pour but final de promouvoir l'efficacité énergétique en milieu industriel en s'appuyant sur les cas de trois grandes industries du pays :

- la SENELEC (Production d'électricité ;
- la SONACOS (Société des oléagineux)
- Les Industries chimiques du Sénégal (ICS.)

Les solutions alternatives qui permettraient de réduire les consommations d'énergie et d'accroître les rendements ont été explorés, les investissements à mettre en œuvre évalués, et la durée de vie des équipements déterminés, ce qui a permis de calculer le coût de revient de la tonne de CO_2 économisée.

Les résultats sont résumés suivant le tableau ci-après :

DESIGNATION		SENELEC C3	SONACOS SEID	ICS MBAO
Horizon temporel		20 ans	15 ans	20 ans
Economie annuelle de combustible en tonne)		6194	26 864	210
Economie totale en tep		113 880	402 960	4 206
Emission de CO_2 évitée en tonne		392 700	1 378 050	13 120
Coûts investissements en millions CFA		2 500	5 294	150
Coût de la tonne de CO_2 Evitée	FCFA	7 450	5 127	11 430
	Dollars / T	12.42	8.54	10

Les résultats au niveau de ces trois établissements montrent des coûts de la tonne de CO_2 fort intéressants sur une période temporelle de 15 à 20 ans correspondant à la durée de vie minimale des investissements à réaliser. Une analyse plus approfondie est sans doute nécessaire pour davantage maîtriser les économies à réaliser.

L'évaluation macro-économique des résultats et l'analyse des stratégies de mise en œuvre des différentes options en cours de finalisation, compléteront l'étude.

Enfin l'ensemble de ces études feront l'objet d'un atelier national de validation.

Climate Change Mitigation Analysis in Lesotho: Progress Report

Mampiti Matete, National University of Lesotho, Lesotho

1 Preamble

Climate change mitigation analysis is one of the activities of the project on "Enabling Activities for the Implementation of the United Nations Framework Convention on Climate Change in Lesotho". The project commenced in October 1996 and is expected to end in August this year (1998). The National Environment Secretariat is responsible for the implementation of the project. The secretariat has however delegated the job to the Lesotho meteorological services department. The director of the department is the supervisor and his deputy, the co-ordinator of the project.

The project involves four activities, viz., inventory collection, vulnerability study, mitigation analysis and adaptation analysis. The first activity is complete while the last three are not yet complete. Ideally, the four activities should have been performed chronologically; meaning that mitigation analysis should have been performed after the completion of the vulnerability study. But because of time constraints and the amount of work involved in each activity, it was agreed that the two be executed concurrently and appropriate adjustments to the mitigation analysis be made later once vulnerability study is complete. Sectors were then identified for mitigation analysis based on the inventory report. The next section provides sectoral classification for the purpose of mitigation analysis. Local capacity building was considered a priority in executing this project. Team composition therefore ensures a section on sector classification, followed by the discussion of the steps involved in mitigation analysis. Finally, a report on activities accomplished by each sector is provided, followed by an account of problems encountered in mitigation analysis.

2 Sector Classification

The sectors analysed in the mitigation analysis were selected based on the amount of green house gases they emit. According to the Lesotho GHG emissions inventory report, energy and land use sectors were identified as the most emitting sectors. The emissions from the land use sector were identified to be coming from: the conversion of grasslands, abandoned managed lands (which comprise a larger percentage of total emissions in the sector) and deforestation.

3 Team Composition

As mentioned earlier on, local capacity building was high in the priorities of the project. Mitigation analysis team comprises multidisciplinary, gender balanced group of four economists, three from the National University of Lesotho and one from the Central Planning Office (two females and two males), one land use planner from the Land Use Planning Division (a female) and one engineer from the energy sector (a male). The team is divided into 2 groups in which a land use planner and an engineer have teamed up with two economists to enhance cross-fertilisation of expertise.

4 Steps involved in the analysis

The analysis comprises six steps:

- Baseline analysis
- options identification
- options assessment
- abatement cost assessment
- stakeholders workshop (including grass-roots level)

  The workshop is intended to create a forum where the team and all stakeholders, including the grass-roots level, can thoroughly discuss the proposed options. This is meant to ensure that the options that are included in the implementation analysis are agreed upon by all stakeholders.

- implementation analysis
- macroeconomic analysis

5 Sectoral Reports

(a) Energy Sector

The energy sector has accomplished step one and is now in the process of identifying and analysing mitigation options. The baseline data was collected and collated based on population figures and projections, GDP figures, national development plans, both short- and long-term and the country vision.

(b) Land Use and Forestry Sector

Baseline analysis for this sector has been completed. The projections of future land uses were made based on major driving forces of land demand. These were found to be population, historical land use trends, development plans (both short- and long-term) and the country vision. The first step of the mitigation analysis is complete while steps two and three are partially finished. The options identified are (a) reforestation of indigenous forests, (b) afforestation of gullies and (c) rehabilitation of wetlands. These options were identified on the basis of environmental problems facing Lesotho, mainly, land degradation. Lesotho is one of the highly (if not the worst) eroded countries in the southern region of Africa. The cause of this problem has been blamed mainly on exploitative use of natural resources that promote soil erosion. To name a few of these exploitative practices, rangelands are indiscriminately burned and overgrazed every year albeit their degraded situation, trees continue to be cut while replanting is on a very small scale, wetlands continue to be destroyed by disturbing their ecosystem and cropland continue to erode due to poor management. Combating land degradation has always been one of the highest priorities in the country’s development plans, but soil erosion continues unabated because of the reasons aforementioned. The options were therefore identified in consultation with relevant authorities and departments to, among other things, consolidate natural resource conservation plans of the country. Also, the three options are cost effective, yet with high benefits, so they were viewed as economically and socially feasible options.

The cost assessment of the three options is complete albeit with difficulties. Because it was difficult to get opportunity costs of most parameters involved in the assessment, financial rather than economic analysis has been employed. It was also not easy to attach monetary values to some parameters like environmental, physical and social impacts associated with the identified options. The analysis was performed manually with the help of spreadsheets. The last two steps have not been performed yet.

6 Problems

Climate change mitigation is a new phenomenon to most countries including Lesotho. The team that is doing the mitigation analysis has never done anything like it before, as such, the task is not a piece of cake. However, it is quite a challenge which the team has eagerly embraced. The problems nevertheless keep on cropping up, as one would expect. The group that is dealing with land use issues is faced with serious literature problems as the available literature is biased towards the energy sector. A lot of developing countries have poor data banks and Lesotho is no different from them. As a result, it is not easy to predict future land use and energy demands. Finally, mitigation analysis team has a problem of accessing reports on finished mitigation studies from other countries.

Addressing Mitigation Options within the South African Country Study

Gina Roos, Eskom, South Africa

1. Introduction

The South African Country Study Programme is being executed under the auspices of the South African Department of Environmental Affairs and Tourism (DEA&T), with funding from the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and the United States Country Studies Program (UCSP). The funding is administered by the South African Foundation for Research and Development (FRD). In order to manage the country study, the principal study coordinator (Dr F Hanekom, Acting Director-General of DEA&T) has convened a sub-committee to the National Committee on Climate Change (NCCC) which is the forum where stakeholders provide input to DEA&T on climate change issues.

The full study comprises the following four components, each headed by a technical coordinator:

- the 1990 greenhouse gas emissions inventory,
- a study of South Africa's vulnerability to climate change and possible adaptation strategies,
- potential mitigation actions and
- policy development.

Ideally, these components should be executed in sequence. However, in view of South Africa's commitments in terms of the Framework Convention on Climate Change (FCCC) and the need to draw up a national communication, it was decided to execute the components simultaneously, with an emphasis on coordination between the components.

Initially, a workshop was held at the FRD, Pretoria from 10 - 12 March 1997, where 37 local and 14 foreign delegates representing government departments, non-government organisations, research organisations (including universities) and public enterprises, had an opportunity to define what the objectives of the individual components should be. It was at this point that delegates agreed that despite South Africa's "non-annex 1" classification as signatory to the Framework Convention on Climate Change, there were still potential benefits for South Africa if they should consider mitigation actions. These benefits included improved efficiencies and technology transfer as well as research and development and information for policy development as well as identifying opportunities for international funding of mitigation options. However, this research and implementation should not occur at the expense of addressing short-term needs such as access to adequate water supplies, housing, education and medical attention. The crux is therefore to evaluate potential mitigation actions to determine whether or not they coincide with national development and economic growth objectives.

The workshop provided the basis for the formal workplan that followed. In turn, the workplan provided a basis for a Call for Proposals for the various study elements. Following is a discussion of the rationale for and structure of the study elements of the mitigation component. Thereafter, the linkages with the other components are highlighted.

Within the mitigation component, there are 9 study elements:

- Coordination.
- Establishing a bottom-up baseline, projecting greenhouse gas emissions under a business-as-usual scenario, from 1990 - 2030.
- Establishing a financial protocol to be used as the basis for all calculations in the sector reviews.
- A short review of possible mitigation actions within each of 6 sectors viz. coal mining, electricity generation, industrial processes, residential and commercial energy consumption, transport and land use and agriculture.
- Provision has been made should any of the options require more detailed research.
- Testing the proposed mitigation actions for their macroeconomic effects.
- Developing a set of socio-economic criteria against which proposed mitigation options should be evaluated.
- Evaluation of the proposed mitigation options against those socio-economic criteria.
- An integration and summary phase.

The work is to be conducted by consultants. Tenders were received and 8 contractual agreements have been reached to date, with two outstanding before work on the mitigation component can commence on the 1 June 1998. The study will run until 30 September 1999.

Before the details on the various elements are discussed, one of the overarching requirements on the project leaders is to take into consideration the results of the regional mitigation studies, in recognition of the regional optimisation that could be achieved.

2. Baseline

There are always a number of debates on the approach to a baseline, specifically:

- whether to use bottom-up or top-down modeling approaches
- whether to make use of "business-as-usual", "optimal development" or "optimal
- whether to develop one "best guess" or several "possible" baselines

For the South African country study, there was general consensus that sufficient confidence could be placed in the direction of economic growth that one baseline would be sufficient. However, it would be necessary to support this baseline with sensitivity analysis to changes in the key assumptions. Again, there was consensus on a "business-as-usual" baseline assumption on the premise that optimal development and optimal adaptation can only be achieved with hindsight. Lastly, a bottom-up approach was seen to be consistent with the sectoral approach to determining potential mitigation strategies.

In order to ensure that the baseline has support from stakeholders, the project leader has been requested to take into consideration a number of independent South African studies and once completed to workshop the baseline at the highest levels.

3. Financial Protocol

In June 1997, the Intergovernmental Panel on Climate Change (IPCC) issued a draft discussion paper on "Mitigation and Adaptation Cost Assessment: Concepts, Methods and Appropriate Use". This has been compiled in order to provide some theoretical input to the non-economists who complete the majority of the country study work. A crucial endpoint of the country study work is to arrive at a cost of implementing potential adaptation and mitigation actions. These figures will also provide the basis for funding negotiations.

In terms of the South African country study, some of the more serious issues that were raised, involved:

- the use of economic opportunity costs as opposed to financial costs
- the implications for funding negotiations of Incremental costs
- the need to consider implementation costs
- how to address costs incurred by different parties over different time periods
- the potential for multi-criteria analysis

Suffice to say that some of the proposals in the draft document were found to represent an ideal situation which may be difficult for non-Annex I countries to implement. However, it was necessary that the issues raised should be comprehensively considered and a standard approach proposed for use by the sectoral project leaders.

4. Sectoral reviews of potential mitigation actions

When the workplan was designed, there was a suggestion to try and base the sectors on the categories segmented in the IPCC guidelines for reporting greenhouse gas emissions. However, this segmentation was not entirely compatible with where the centres of expertise lay in South Africa. It was decided to proceed with the six broad categories outlined above, which can also be interfaced more easily with the macroeconomic study that is to follow. There was also a consensus that as a non-Annex I signatory, South Africa should only pursue "no regrets" and low cost mitigation options or those options which would be eligible for international funding under the climate change convention or the Kyoto protocol i.e. those which would not compromise South Africa's development and economic goals. It was in this spirit, that project leaders were also requested to consider behavioural and not just technological actions.

5. Macroeconomic study

The need for this component was highlighted in the IPCC draft discussion document discussed above - where there were barriers to proposed mitigation actions that had not been detected in the bottom-up studies. However, there appear to be technical difficulties with macroeconomic modeling, in that:

- they do not consider the informal sector so prominent in many developing economies,
- there is a lack of stability for longer term modeling and
- mitigation actions undertaken at the sectoral level may not have a significant influence on macroeconomic indicators.

It has therefore been proposed that the focus of the macroeconomic modeling be expanded to include testing of national mitigation policies, where more useful results might be obtained.

6. Evaluation Criteria

This project was initiated to ensure that the identified mitigation options would be compatible with national development and economic goals. It has been anticipated that there is a lack of information concerning social costs in South Africa and another way to address these costs is to use multi-criteria decision-making, where social and other environmental impacts are taken into consideration.

7. Integration

Finally, the results from the above studies need to be integrated into a cohesive study from which a final report will be compiled. It was decided that the project leaders for this section should be contracted for the full study period and not only after all the individual projects have been completed. This will ensure the project leader's familiarity with all the project components to be integrated.

Apart from the details of the individual study elements discussed above, there are two additional areas to address viz. coordination between the components and difficulties experienced with the process so far.

Since the emissions inventory component has already commenced and most of the mitigation project leaders have been identified, it has been possible to put groups in contact with each other where they are considering similar areas. For example, in the emissions inventory there was an expert group considering 1990 greenhouse gas emissions from coal mining in South Africa. Where possible, the project leader for mitigation activities in the coal-mining sector has attended the emissions group's feedback meetings.

Coordination with the vulnerability and adaptation component is more complex. Firstly, due to the time horizons involved, it is necessary for the vulnerability and adaptation project leaders to consider the socio-economic projections derived in the baseline study which is being conducted under the auspices of the mitigation component. Secondly, estimating the costs of adaptation are equally important for policy development and the vulnerability and adaptation project leaders will also need to be considered in the Mitigation's financial protocol study. Thirdly, the sectors that will potentially be affected by climate change and the sectors that will be required to mitigate against climate change are usually not the same. Therefore, substantial effort will be required to integrate the results from the vulnerability and adaptation component and the mitigation component. In the South African country study, this has been treated as part of the policy development process that takes place in the policy component. Lastly, there may be areas where adaptation or mitigation have secondary effects in term of mitigation or adaptation respectively.

Finally, it is important to highlight the difficulties experienced so far in the country study process, most of which concern the design of the study elements. Since one person cannot undertake the entire study, it has to be broken up into study elements. The detailed specification of what each element entails and how it dovetails with the others is considered to be the most important factor in the successful completion of the study. Traditionally, the consultants have worked within their individual spheres of expertise, where addressing the causes and effects of climate change could affect every sphere of life.

Capacity Building in Greenhouse Gas Mitigation Studies in Africa: The UNDP/GEF Project RAF/93/G31

Dr Moussa Kola Cisse, Enda Energy, Dakar, Senegal

1 Introduction

Greenhouse gas mitigation studies are an essential aspect of developing country commitments, as set forth in article 4 of the United Nations Framework Convention on Climate Change (UNFCCC), and occupy a primary position in their national communications, as expressed in article 12 of the same convention. Furthermore, the operational strategy of the Global Environment Facility (GEF) considers the studies to be a priority in its enabling activities, designed to build the indigenous capacity of developing countries. This is the context for Project RAF/93/G31, aimed at capacity building in sub-Saharan Africa and initiated in November 1995. The project covers four countries, Ghana, Kenya, Mali and Zimbabwe.

The decision to implement the project in these countries has its roots in the concern that they had insufficient knowledge and expertise to conform to the provisions of the convention; that the links between climate change mitigation studies and the realisation of national sustainable development objectives were little known; and that there was little capacity in these countries for maximising the potential offered at the international level in climate change affairs.

The project strategy concentrated on institutional and technical capacity building adapted to the particular situation of the region, based on training and awareness raising activities and actions covering various aspects of the implementation of the Convention: informing decision-makers, researchers, NGOs and grassroots populations; strengthening the national executive structure; conducting technical studies (inventories, review of national policies, mitigation and vulnerability and adaptation studies); and participating in international meetings. The strategy, with the regional coordination of Enda TM, places national and regional expertise to the fore.

The notion of capacity building in greenhouse gas mitigation studies is found in the context of this general strategy, whereby implementation at the national level devolves on a national executive structure supported by a multidisciplinary and multi-sectoral national team. The mitigation studies carried out in the various countries are based on this approach, from which a number of important lessons can be drawn.

2 Training

The principle documents which formed the basis of Enda's training programmes were: UNEP/Risø (Economics of Greenhouse Gas Limitations - GF/2200-96-15); Methodological Guidelines-document 04408.02/02, Draft, March 1997); Greenhouse Gas Mitigation Assessment: a Guidebook; Techniques, politiques et mesures d'attenuation des changements climatiques, IPCC Technical Document I; CC: Train Training Module I on mitigation analysis. The 5-day training programmes aimed at building the capacity of the national teams charged with mitigation studies by making methodological tools available to them. The main themes were:

- Methodology for analysing greenhouse gas mitigation options

- Analysis of national development policy and its relation to climate change
- Presentation of models of analysis
- Methodology of construction of base scenarios
- Analysis and choice of technological options
- Methodology of construction of mitigation scenarios
- Analysis of the impacts of mitigation options
- Elaboration of national mitigation strategies
- Scheduling mitigation studies

Sectoral groups, which conformed to the inventory modules (energy, industrial processes, agriculture, forestry and land use changes, waste), were formed according to the various themes, in order to discuss the national situation and propose options for exploration. LEAP, an integrated planning model, was presented and used in order to illustrate the construction of base scenarios and mitigation scenarios in the energy sector.

To implement the programme countries needed at least a provisional inventory report. They then proceeded to an analysis of national development policy in relation to climate change. For the purposes of training, national teams were asked to prepare sectoral and socio-economic information and data on the basis of a checklist in order to manipulate the models for constructing scenarios.

One factor in the success of such a seminar is the constitution of the national team: i.e. the profile of participants. One criticism was that the national teams were largely made up of specialists in each sector (energy experts, agronomists, foresters, industrial engineers, etc.) to the detriment of economists. In choosing participants in each country, technological aspects were prioritised over socio-economic aspects, which however form the basis of the analytical methodology of mitigation studies. In addition, the majority of members of the national teams were dealing with these issues for the first time and were neither familiar with the models nor in possession of the appropriate information for their use. This is why assistance in conducting the studies was required - capacity building strategy is not simply about training. As regards the constitution of the teams, certain sectors were under-represented, in particular the waste sector.

Evaluations of the training emphasised that the scope of certain themes must be broadened. These included the presentation and use of the models for socio-economic and sector analysis, as well as improving the working groups by including economists.

Above and beyond the acquisition of knowledge, the results of this type of training are have an impact on the identification of the sectors to be studied, the definition of terms of reference, the constitution of working groups and the elaboration of work plans.

3 Conducting mitigation studies

The strategy of conducting mitigation studies was formulated on the principle of training through action. National teams were given a chance to apply the tools that they had been given in a process of assisted apprenticeship.

Work plans were established in the course of the seminar identifying the tasks to be performed by each working group and the deadlines. The following were the principle tasks identified: approval of the choice of sectors; establishment of an information and data check-list; data collection; preparation of the base situation; identification and choice of analytical models; construction of mitigation scenarios; evaluation of socio-economic impacts; elaboration of implementation strategies. Deadlines approximating five (5) months were given for the completion of the mitigation studies. In general the studies covered the energy, agricultural and forestry sectors, since these are the most significant in the inventories of the countries and in their development policies.

Structures for the studies were made available to the working groups, outlining the different aspects of analysis, including: context (objectives of the study, definition of the problem, justification of sector choice, justification of deadlines); presentation and analysis of a base situation (socio-economic projections, emission projections); analysis of national and sector development policy (identification and choice of referential options, definition of the parameters of projection); projection of a base scenario (socio-economic projection, emission projections); projection of mitigation scenarios (identification and choice of mitigation options, projection of actions and of emissions); evaluation of mitigation options (definition of criteria and methods of evaluation, analysis of impacts); elaboration of implantation strategies (identification of actors, definition of means, implementation plan, accompanying measures).

Progress reports are regularly submitted to Enda for commentary. The reports have been improving progressively, in form as well as content, since the process began. This exercise has also allowed occasional confusions to be cleared up, and the monitor-evaluation missions have taken on the flavour of action-training missions where precise concerns can be addressed and appropriate directives given.

The main difficulties encountered in conducting the mitigation studies have been in the area of identification and collection of basic historic data in the relevant sectors. In countries where information was collected by working groups dealing with the inventories and the review of national policy the problems were less pronounced. Otherwise, the main problem concerned the treatment of data and was due to a weak grasp of the analytical methods in use. In certain cases working groups were working in parallel (inventory and national policy review), without consultation, which brought up problems of data consistency, choice of deadline, and the parameters for projecting activities and emissions. The weak socio-economic evaluations are down to the relative absence of economists in the working groups.

4 Conclusion

Our experience of capacity building in mitigation studies was very enriching. The establishment of working groups trained and launched towards a certain objective, is a significant contribution in terms of human resource development for the countries in question. Certain countries had already benefited from mitigation studies as part of external collaboration, but on analysis the impact of these activities has been very limited because of the preponderance of external expertise.

In terms of methodology, the sector-based approach chosen by the various teams was driven by a desire to propose sector-based projects that may address the developmental perspectives of the countries in question and which can contribute to the limitation of greenhouse gas emissions. It is further justified by the insufficiency of macro-economic data for tendency analyses, the preponderance of short-term problems, the prioritisation of sector-based projects to improve the standard of living of populations, and the shortage of expertise and data for macro-economic modelling.

Mitigation Options in Forestry, Land-Use Change and Biomass Burning in Africa

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Abstract

Mitigation options to reduce greenhouse gas emissions and sequester carbon in land use sectors are describe in some detail. The paper highlights those options in the forestry sector, which are more relevant to different parts of Africa. It briefly outlines a bottom-up methodological framework for comprehensively assessing mitigation options in land use sectors. This method emphasizes the application of end-use demand projections to construct baseline and mitigation scenarios and explicitly addresses the carbon storage potential on land and in wood products, as well as use of wood to substitute for fossil fuels. Cost-effectiveness indicators for ranking mitigation options are proposed, including those which account for non-carbon monetary benefits such as those derived from forest products, as well as opportunity cost of pursuing specific mitigation option. The paper finally surveys the likely policies, barriers and incentives to implement such mitigation options in African countries.

1 Introduction

The biomass sector provides the most important near-term opportunities for reducing greenhouse gas (GHG) emissions and sequestering carbon in Africa. In this paper, we briefly describe assessment of mitigation options in forestry, agriculture and other land-use such as range and grasslands. Mitigation options as used here refer to those measures and policies which can lead to a reduction in the emission of greenhouse gases from the biomass sectors and/or through increased absorption and storage of carbon, both in perennial vegetation, detritus, soils, and in long-term biomass products. In most land- use changes involving decomposition and oxidation, GHG may be emitted. They include carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), nitrous oxide (N_2O), oxides of nitrogen (NO_x) and other non-methane hydrocarbons (NMHC). Although CO_2 forms the bulk of these gases emitted in the biomass sectors, it can be reabsorbed by vegetation via the process of photosynthesis and through organic matter replenishment in soils. On the other hand, the emitted trace gases accumulate in the atmosphere for their entire residence period.

It is estimated that net carbon emissions from the biomass sectors amount to 1.6 +- 1.0 billion tonnes per year, most of which originate from lower latitudes, and that forests from the mid and high latitudes have a net sequestration of 0.7 +/- 0.4 billion tonnes per year [1]. Africa's share of anthropogenic emission of greenhouse gases has been estimated at about 4% of global net emissions, adding to about 0.3 billion tonnes of carbon per year, mostly from forestry and land-use changes [2]. Despite the relatively low contribution to the atmospheric accumulation of GHG, Africa has a large potential of increasing the emissions from land-use changes due to persistent dependence on primary resources for subsistence farming and over dependence on biomass as a primary source of energy. The Zaire basin alone has a large reservoir of carbon estimated to exceed 20 billion tonnes. Under current or accelerated rate of depletion of the region's forests, most of this carbon can be released in a few decades. On the other hand, Africa has a large expanse of arable land, which could be used to undertake various mitigation measures intended to increase the stock of carbon stored on land.

The purpose of this paper is to examine the likely mitigation options in the biomass sector in the Africa region and briefly describe the approach used by the participating countries whose work is presented in this volume. The most applicable options for the region include forest protection and conservation, improved forest management, the use of improved cook stoves, short- and long-rotation forest plantations, agroforestry and natural regeneration, and the expanded use of sustainably procured timber and non-timber wood products. These options are described below in the context of their viability in the region. Finally, the paper briefly explores the policy instruments, incentives and barriers for implementation of such options in Africa.

2 Mitigation Options in the Biomass Sectors

The main purpose of forestry mitigation options is terrestrial carbon storage, which would reduce atmospheric accumulation and thus delay its impact on global climate. Mitigation options may be classified into three basic types3. One option is to **expand** vegetation stocks and the pool of carbon in wood products. Expansion will capture carbon from the atmosphere and maintain it on land over decades. The second option is to **maintain** carbon stocks in existing stands of trees and the proportion of forest products currently in use. Maintenance of existing stands, whether achieved through reduced deforestation, forest protection or through improved cook stoves, lengthens the duration the carbon stays trapped in woody vegetation. For example, tropical forest vegetation and soils contain 20-100 times the amount of carbon in crop and in pasture lands. Hence maintenance of these forests instead of converting them to croplands or pasture is an effective mitigation option, but difficult to implement, as long as the land is often more valuable deforested than forested [4].

A third avenue to reduce carbon emissions is to **substitute wood** obtained from sustainable sources **for other emission-intensive products,** particularly fossil fuels and unsustainably produced wood [5]. Fossil fuel substitution with biomass derived from sustainably managed renewable sources, will delay or avoid the release of carbon from the fossil fuel. This substitution also applies to products such as construction material of which production leads to substantial emissions. Cement and synthetic material are good examples.

2.1 Emission Reduction Options

(i) *Forest Protection and Conservation*

These options protect the carbon and other GHG in both the vegetation and soil. Such measures will be in projects or initiatives that are usually put in place for resource management purposes, often unrelated to carbon-emission considerations. There are opportunities in many African countries to establish or strengthen wildlife protection, soil conservation, water catchment preservation, and recreational reserves that will also reduce eminent carbon emissions and sequester carbon if the biomass density increases. Measures to reduce losses from insects and diseases should also be considered under this category, although this may not be a priority option.

(ii) *Efficiency Improvements*

(a) Natural forest management such as emphasizing forest for multiple end-uses

(b) Harvesting of natural forests which may involve increasing the capacity to utilize silviculturally optimum selective-harvesting regimes e.g. reduced impact logging. Measures to increase biomass extraction rates will reduce the amount of biomass left on site for decomposition.
(c) Undertake salvage operations during conversion of forests to other land uses like hydropower development, or road construction.
(d) Improvements in the product conversion and utilization efficiency can reduce emissions significantly. Such measures may involve technological intervention and will tend to find wide applicability in a region of which forest industries are dominated by mills which have a conversion efficiency of less than 25 percent in pitsawing and about 40 percent in conventional sawmills [6]. Improving various operational aspects of machinery and equipment in the wood industries may boost the amount of biomass converted to wood products by a significant proportion. Replacing the old generation of mills in the sector by a newer vintage can easily double the conversion efficiency in some cases. Installing capacities for residue utilization for bio-fuels and tertiary products also maximizes useful biomass utilization and reduces emissions.

(iii) *Bio-energy Initiatives*

These would tend to be attractive in a region of which about 75% of its primary energy demand is biomass based, with a few countries like Tanzania and Ethiopia exceeding 95 percent. The mitigation options in the bio-energy field will mainly reduce the use of biomass and thus maintain stocks of carbon, while refraining emission of trace GHGs. According to the revised IPCC methodology [7], all net emissions from biomass burning should be considered as loss of forest stocks. Options that can be considered here include:

(a) more efficient kilns for charcoal production and introduction of less wasteful charcoal packaging e.g. briquetting. The traditional charcoal kilns that are widely used in the region have an average efficiency of 20 percent, while the newer metal kilns average at about 30 percent [8]. Compared to efficient kilns used elsewhere, there is general consensus that charcoal production efficiency can be brought up to 50 percent in field conditions, a measure which will have a commensurate reduction of emissions.
(b) improved woodfuel stoves for firewood and charcoal for household and for small-scale industry such as pottery, restaurants, etc will cut emissions in proportion to the boost in efficiency. Studies done on dissemination of the Kenya Jiko and similar devices point out that with modest investment and strategically targeted programs, efficient stoves could replace most of the inefficient stoves in a decade or two [9].
(c) improved use of charcoal for industry such as steel production, as well as more efficient use of wood in agriculture such as in the curing of tobacco and tea.
(d) use of sustainably grown biomass for fossil fuel substitution is a viable option in a few African countries where the use of fossil fuels is a large and growing share of the energy basket. South Africa and Zimbabwe are examples of countries that could use this option to reduce their coal consumption.
(e) A major emission reduction option involves the use of sustainably grown wood e.g. woodfuel plantations, village woodlots, etc, to substitute for fuelwood from natural forests which are being depleted at an accelerated pace throughout the continent. For example, it is estimated that in 1990, Tanzania lost about 227,000 hectares of woodlands to production of charcoal and firewood [10].

(iv) Reducing emissions from land-use changes.

(a) Permanent intensive agriculture/pasture is a good long-term mitigation option to reduce emissions from land use changes that involve shifting agriculture or pasture. This requires investment in the necessary infrastructure and extension services necessary to convert shifting farmers/ranchers into sedentary land users. This option should be examined in the context of the respective country's rural development goals and policies.

(b) Supplementary economic activities for shifting farmers may boost their earnings and as such reduce their demand on forest land for subsistence. Measures which increase the opportunities for harvesting and marketing of non-timber forest products such as nuts, honey and fiber are good candidates. Also, introducing small-scale rural industries such as carpentry, brick making, weaving, etc may stem the rate of deforestation associated with subsistence farming. This option can not be treated in isolation from the country's rural development plans. However, within the development context, such an option should be very attractive.

(v) Wild-fire management

Since large areas of African savannas and woodlands are torched every year, management of these fires is an attractive option for reducing carbon and trace gas emissions. If one assumes that non-crown forest fires do not result into net carbon emissions, then the mitigation options to be considered for forest fires are those intended to avoid catastrophic fires that char woody biomass. The most applicable measure in the region would involve prescribed burning which regularly reduces the fuel load.

The biomass burning associated with annual vegetation like savannas emit trace gases such as CH_4, N_2O and NO_x. There are no obvious mitigation measures to reduce trace gases from savanna fires due to the fact that most of the fires are natural. Although burning biomass at a higher efficiency reduces the amount of trace gases emitted, the fire management techniques required given the size of savannas annually on fire, would tend to make this option of lower priority in the region.

(vi) Wildlife and range management

Mitigation options to reduce emissions from rangelands with wildlife or domesticated animals involve improved range management, wildfire prevention and control as well as good animal husbandry, including sustaining numbers which are within the carrying capacity of the range.

2.2 Options to Sequester Carbon

Each one of the options under this category has to be separately identified and described depending on the end-use for which the new biomass is intended or depending on the fate of the new land use. These would include: forest products such as woodfuel, timber, pulp and paper; forest services like recreation, soil protection, emission reduction through fossil fuel substitution, etc. The fate of the biomass is critical in determining the carbon flows, cost and benefit streams, as well as the implementation possibilities of the specific mitigation option as listed below:

(*i) Afforestation* - Planting forests in bare land, with biomass density commensurate to the objective of the project. These options will be more acceptable if they correspond to the forest resource management aspirations of the country.

(ii) Reforestation - Replanting and/or natural regeneration of deforested or degraded lands will restock the area, and provide a future use of the forest in a more sustainable fashion, meanwhile sequestering carbon from the atmosphere. Enhanced regeneration can be considered here so as to increase the biomass density of understocked areas.

(iii) Agroforestry - The set of mitigation options that fall under this category will find favor with policy makers in many countries in Africa. It has been shown that this option is highly desirable for rural areas where it provides a variety of other goods and services, on top of being cost effective for carbon sequestration purposes [11]. Some or all of the agroforestry forms practised in various areas may be applicable to different suitable sites in any given county in the region. The most commonly practised forms are:

(a) inter-cropping for the purpose of producing both agricultural and forest products,
(b) boundary and contour planting for wind and soil protection, and for wood products,
(c) taungya system applied as an integral part of forest management, in natural and plantation forestry,
(d) pastro-silviculture for producing both forest and animal husbandry products,
(e) non-timber tree farms such as those for rubber, tannins, bamboos, rattan, etc.

(iv) Urban and Community Forestry - here we include the additional biomass in non-contiguous tree cover such as residential shade trees, road side and demarcation trees in the rural areas, etc. Also to be considered is expanded urban forestry which sequesters carbon as well as reduce emissions through cooling and heating of urban residential and commercial buildings. This option is more attractive to those countries with a large urban population. Given current urbanization trends, many countries in the region will have a majority of their citizens in urban areas in the coming decade or so, and as such this option may be increasingly attractive.

(vi) Range and grasslands - options to sequester carbon in rangelands involve improved range management, especially biomass replenishment. In grasslands and rangelands, most of the carbon sequestration takes place below ground, and has a longer half-life than carbon sequestered above ground [12]. These options would seem appropriate for the over-grazed areas of the rangelands of the west, east and southern Africa.

Each of the above options is influenced by broader cross-sectoral issues rooted in the country's land-use policy and law, which together with institutional arrangements are critical for the viability and implementation of any mitigation package. How each country chooses a set of mitigation options to consider for implementation depends on the results of thorough and systematic evaluation of all the major available options.

3 Evaluation of Mitigation Options

Past analyses of the costs, benefits, and economics of forest sector mitigation options have varied in the extent and treatment of components which should be included in mitigation assessment. The most commonly examined items include infrastructure and establishment costs, initial capital requirements, and the amount of GHG emission reduction. The more sophisticated studies have tried to look at the opportunity cost of land and growing stock, as well as total monetary benefits and costs. The less commonly included components in mitigation assessments are: non-monetizable costs and benefits, net present value (NPV) of finite or perpetual number of rotations, indirect impacts at local, regional, national and at international levels, as well as other environmental impacts such as bio-diversity. Here we briefly outline a recommended approach for mitigation assessment in land-use change sectors following Sathaye *et al*, 1995 [13].

3.1 Summary of the Comprehensive Mitigation Assessment Process (COMAP)

The approach suggested here involves several steps. The first step involves a preliminary screening which is used to eliminate those options with least likelihood of implementation in the country for any number of reasons, including but not limited to; conformity with existing forest management plans, equity and co-benefits issues, feasibility and/or ease of implementation, or ecological soundness of the option. Two other criteria that need to carefully be consulted are *biophysical and political considerations.* On the first count, options may be screened out due to site specific biological or physiographic reasons such as climate, soil, drainage, altitude, etc. On the other hand, those options that are expected to significantly infringe on the sovereignty of the country, or might tend to cause instability such as massive relocation of forest dependent populations may be ruled out of consideration on political grounds. Given the delicate environment and socio-political climate in the region, it behooves African countries to carefully take such considerations into account.

After identifying the set of implementable options, one determines the forest and agricultural land area that might be available to meet current and future demand for wood products (both domestic and export) and services. Demand for wood products includes that for fuel wood, industrial wood products, construction timber, etc. Potentially surplus land in the future may be used solely for carbon sequestration or other environmental purposes. On the other hand, in many countries not enough land may be available, in which case some of the wood demand may have to be met through increased wood imports or through substitutes such as kerosene for woodfuel. Alternative combinations of future land use and wood product demand patterns will lead to different scenarios of the future. The most likely trends scenario is chosen as the baseline scenario, against which the others are compared.

The mitigation options are then matched with the types of future wood-products that will be demanded and with the type of land that will be available. This matching requires iterating between satisfying the demand for wood products and land availability considerations. Based on this information, the potential for carbon sequestration and the costs and benefits per hectare of each mitigation option are determined. The GHG flows and cost/benefit information are used to establish the cost-effectiveness of each option by use of a set of criteria such per unit area or tonne of carbon. Such indicators include (i) initial cost, (ii) present value of cost, (iii) net present value and (iv) benefits of reducing atmospheric carbon. In addition, the information, in combination with land use scenarios, is used to estimate the total and average cost of carbon sequestration. Finally, the barriers, policies and incentives needed for the implementation of each scenario are explored.

Assessment of the macro-economic effects of each scenario, on employment, balance of payments, gross domestic product, capital investment, may be carried out using formal economic models or a simple assessment methodology

4 Mitigation Policies, Barriers and Incentives

4.1 Identifying Implementation Policies

Having constructed the baseline and mitigation scenarios, one has to identify and describe the policies that may be necessary to implement the mitigation options. These policies can be divided into two groups: (1) biomass sector policies which govern the use of forest resources, and (2) non-biomass sector policies which happen to influence what happens in the biomass sector.

Biomass sector policies

The policies to be considered here are those which will either be used to maintain carbon stocks and/or expand carbon sinks. Such policies may include:

(i) Forest protection and conservation policies. Here one has to consider both national, regional and local measures to preserve existing vegetation cover. For example, local or national laws prohibiting conversion of steep slopes to agricultural lands, or gazetting vulnerable ecosystems into nature reserves.

(ii) Policies on shared responsibility for managing existing protected areas between local communities and the central agencies, which also include the sharing of benefits from the protected area tend to reduce "encroachment" by the surrounding population. Such policies have been applied effectively in many developing countries. A recent example is the shared wildlife management in Zimbabwe.

(iii) Policies governing terms of timber harvest concessions covering allowable cut, concession duration, levels and structures of fees and royalties will influence the implementation and effectiveness of the mitigation options in efficiency improvements. These policies may even include logging ban in specified ecosystems. Policies which emphasize export of higher value timber products and ultimately a ban on log exports may reduce the rate of forest degradation associated with the forest sector's contribution to the country's foreign exchange earnings.

(iv) Tax rebates and dissemination policies governing the adoption of efficient charcoal kilns and wood stoves have been shown to substantially affect success of such programs in the bio-energy field. The experiences of Kenya, Tanzania and Malawi are pertinent to these policies.

(v) Aggressive afforestation and reforestation policies both by villagers and forest departments will help expand the carbon sinks in the country, including incentives for private ownership of some forest resources.

Non-biomass sector policies

These policies are intended for the management of the other sectors of the economy, but have large influences on the depletion of the carbon stock, and at times may provide a disincentive to increasing forest and rangeland cover. The mitigation policies which lie in this area are:

(i) Land tenure policies that do not encourage private ownership of public lands with an express mandate to develop the land. Policies to the contrary have been shown to encourage wasteful conversion of forests to other land uses so as to meet the criteria for property rights assignment.

(ii) Land tenure policies that increase the certainty of tenure tend to make the owners of the land to plant and retain trees on their land. Such policies will be necessary in those mitigation options in agroforestry and of woodfuel plantations.

(iii) Agricultural policies that do not encourage extensive and wasteful conversion of natural forests to agricultural lands. Policies which emphasize more intensive farming and conversion of less marginal woodlands tend to lead to production of the same agricultural output from less area, using the same amount of resources. To an extent, similar policies can selectively be applied to pasture management.

(iv) Infra-structural policies governing mining, dam construction, road construction can reduce unnecessary emissions.

(ii) Taxes, credits, and pricing policies also play an important part In many African countries, the Stumpage price is too low to guarantee a supply of funds to reforest and manage the logging areas.

4.2 Barriers and Incentives for Implementation

The policies described in the last section may not easily be translated to mitigation programs/measures due to the existence of barriers and lack of incentives to implement them. A diverse array of criteria will have to be satisfied before a project can be implemented. The analyst should identify, describe and propose likely solutions to these barriers. The most common barriers to the implementation of biomass sector options can be divided into three categories:

(1) Technical and Personnel Barriers

In most countries in Africa, the lack of scientific data on silvicultural, ecosystem management and pastoral practices, including soil conservation; is a serious impediment in evaluation and implementation of various options. This is a serious impediment in Africa. Availability of seed material, research on species provenance multi-cultural management including harvesting techniques, silvi-pastoral systems etc may be lacking for individual sites. Also, in the short to medium term, there may be a lack of qualified local personnel to carry out the projects as well as provide extension services necessary for the successful involvement of local populations.

(2) Financial and Resource Barriers

Funding of forestry projects and rangeland management projects has been very low in most cases. Participation of the commercial sector may depend on availability of incentives for long term investment in the biomass sectors. The borrowing rates from banks may be too high for private investors and or local communities to get credit for these projects. Bilateral and foreign-source funds are restricted to those areas that are more profitable, and as such there may not be enough funds for broad investment in the identified response options. Other sectors like agriculture may compete for labor with the above mentioned biomass sectors, depending on the types of crops and the seasonal demands on labor. Procedures and mechanisms for identifying of beneficiaries, cost-bearers and ways to apportion credit from the options may be a barrier to implementation.

(3) Institutional and Policy Barriers

Land tenure and land law may prove to be the strongest hindrance in implementing the mitigation options, especially in this region where land and politics are so intertwined. Also, institutions necessary to allow for participation of various parties in the options may not exist in the country. For example, there may not be a mechanism for sharing benefits between the central authorities and the local participants in community-based mitigation options. Policy barriers to harvesting, marketing of forest products, pricing, tariffs and quotas for exports and imports may also hinder implementation of some of the mitigation options.

The scenarios provide useful information to policy-makers regarding the total and average cost to sequester carbon. However, this information is not adequate to develop policies and measures to implement climate change mitigation projects. A diverse array of criteria will have to be satisfied before a project can be implemented. These may include the ease of implementation, identification of the project's beneficiaries and losers, together with institutional and legal considerations.

5 Conclusions

This paper lists the mitigation options in forestry, land-use change and biomass burning as relevant to African countries. It briefly describes a bottom-up methodological framework for assessing mitigation options that include the use of specific cost effectiveness indicators for ranking mitigation options. The approach pays explicit attention to non-carbon monetary benefits, like those derived from forest products, which may completely offset a project's cost and the opportunity costs of pursuing forestry options. The paper finally surveys the likely policies, barriers and incentives to implement such mitigation options in the region.

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Regional Climate Change Mitigation Analysis

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1 Introduction

The purpose of this paper is to explore some of the key methodological issues that arise from an analysis of regional climate change mitigation options.1 To do this, the paper is divided into seven sections. After this brief introduction, the second section describes the context in which the work has been undertaken. The third investigates the rationale for any analysis of *regional* mitigation activities, emphasising both the theoretical attractiveness and the existing political encouragement. The fourth, fifth and sixth sections review the methodology that has been developed. In these sections, the differences arising from the fact that mitigation analyses have been taken from the level of the national – where the majority of the work has been completed to date – to the level of the international – that is, the 'regional' – will be especially highlighted. Finally, in the seventh section, a summary is provided and some concluding remarks are offered.

2 Context

As part of the GEF/UNEP project on 'Economics of Greenhouse Gas Limitations' – which includes many of the national mitigation studies that have been presented during this conference – there was an investigation into how neighbouring countries, working together, could mitigate global climate change. Though the exploratory nature of the work necessarily meant that restrictions were not placed upon the researchers at the outset, it was generally anticipated that 'regional mitigation options' would consider instances in which entities in two or more neighbouring countries take consciously co-ordinated action to promote global climate change mitigation. Examples might include, for one, the development of a particular project, whose go-ahead was contingent upon the commitment of actors in two or more countries. Such multicountry participation may be necessary for any of a variety of reasons – for instance, to guarantee markets for the project's outputs. Exploitation of a shared resource and harmonisation of international policies regarding trade or transportation are but a couple of additional examples.

The ambition was primarily twofold: first, to advance methodological development; and second, to investigate further the methodology – in a very exploratory manner – by looking at potential regional mitigation activity in two parts of the world: the countries of the Southern African Development Community (SADC) and the Andean Pact group of countries in South America. Consequently, work has progressed during the past two years – by a group based at the UNEP Centre in Denmark, as well as colleagues in both southern Africa and South America. And, indeed, in the subsequent two presentations, you will hear from some of these colleagues about the specific work that they have been undertaking on the southern African study. My comments, meanwhile, are of a more general nature – reporting upon the work that we at the UNEP Centre have been involved in, which has largely focussed upon methodological issues.

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1 The arguments in this paper are drawn primarily from Rowlands (1998a) and Rowlands (1998b).

3 Motivation

The motivation for investigating regional mitigation options is that they offer, at least in theory, 'better' alternatives. Support for this statement is provided by the fact that regional mitigation options could help to achieve one or more of the following goals:

- increasing the portfolio of available actions (that is, a new option appears where, when analysing countries on their own, one was not available): for example, neither country may have considered the development of a hydropower facility, because it would have provided too much electricity needs for either country on their own; together, however, the project is made plausible.

- reducing the cost of existing actions: for example, the development of a regional market may serve to lessen the costs of implementing a particular energy efficiency technology.

- permitting more equitable outcomes to be realised: for example, agreement of common regional standards may mean that renewable energy is subsequently accessible to a greater proportion of the population.

There is additionally, support given to regional action in the broader international regime. The preamble to the UN Framework Convention on Climate Change (FCCC) recognises the global nature of climate change and 'calls for the widest possible cooperation by all countries…' (UNFCCC, 1992, paragraph 6). In the list of principles intended to guide the Parties, it is noted that 'Efforts to address climate change may be carried out cooperatively by interested Parties' (UNFCCC, 1992, Article 3.3).

Moving away from the general and towards the specific in the FCCC, there are a number of suggestions about the kind of cooperative action that could take place. Article 4.1 is the section of the Convention that contains the longest list, and it commands Parties to, among other things, cooperate in technology development and diffusion, sink and reservoir conservation and enhancement, preparing for adaptation, research and observation, and education and training. These prescriptions are quite wide-ranging (UNFCCC, 1992).

There is also the much cited Article 4.2(a) of the Convention, in which it is noted that Parties 'may implement such policies and measures jointly with other Parties…' Article 4.2(d) does go so far as to call this 'joint implementation' (UNFCCC, 1992).

Moreover, joint reporting among regional neighbours is permitted by Article 4.1(b), while the participation of 'regional economic integration organisations' –
by the terms of the Convention (UNFCCC, 1992, Articles 18, 20 and 22). Now REIO, in the FCCC process to date, has basically been a euphemism for the European Community – presently the only non-state entity to be a Party to the Convention. However, there is conceivably nothing that holds back other REIOs from pondering participation in this way.

Consequently, the Convention itself – even before events at Kyoto (which I will touch upon in the panel discussion later this morning) – lends encouragement to exploration of regional actions, regional mitigation activities included.

4 Methodology I: Abatement potential and cost

Having provided some justification for why we are thinking about regional mitigation analysis, I would now like to examine the methodology used – that is, the path that was followed in order to uncover information about regional mitigation activities, particularly their abatement potential, financial cost, developmental impacts and implementation prospects. We thought that it would be advantageous if we could keep the methodology as general as possible, to – potentially – be as widely applicable as possible.

We began by thinking that the methodology for national mitigation studies – that which the country studies you have been hearing about during the last couple of days have been using – would be a wise point of departure for regional mitigation assessment. After having been through the exercise, we still maintain that it is a very useful guide; nevertheless, it is still interesting to see how new issues are introduced by virtue of the fact that we are taking the analysis from the level of the nation-state to that of the international (see also Appendix I).

Indeed, differences arise when we begin to think about the baseline – that is, our best guess of what would happen over the next 30-50 years in the absence of any climate change-inspired activity. Although, conceptually, this should simply be the aggregation of the different baselines for the countries of the region – for the countries together constitute the region – potential problems arise once we move on to actual construction of the baseline.

Consider, for one, the possibility that different assumptions have been made in construction of the different national baselines – one country, for example, may have envisaged a particular level of future trade or a particular trajectory of technological development, while another may not have foreseen the same. Such inconsistencies have to be eliminated and therefore some best guesses as to ‘the future’ will have to be made. This may involve the development of some kind of ‘regional story’ – that is, an agreed picture of the region’s future in terms of key economic and social indicators.

A next step would then be to identify and analyse a regional mitigation option – that is, something that is contingent upon coordinated action among entities in two or more the region’s countries. After identifying it – and I hope by now you have a flavour for potential candidates – there is then the task of costing it in terms of net quantity of greenhouse gases (GHGs) abated and money.

A challenge, however, arises after we recognise – as did WGIII of the IPCC – that ‘cost-benefit assessments need to be informed by an understanding of different perceptions and priorities among countries and the importance of time horizons in different regions’ (IPCC, 1996, 68). This obviously has implications for a regional study – in ‘costing’, whose perceptions and priorities should be used? should some sort of average or median be calculated?, if so, how should it be weighted? Differences of opinion about the appropriate discount rate to use, or about the future acceptability of different technologies are just two explicit examples. Obviously, such challenges also arise in national studies, for there are groups of people with different perceptions and priorities *within* individual countries. Consequently, our challenge may simply be resulting from an increased order of magnitude – that is, larger areas, increased number of cultures, jurisdictions and so on. Alternatively, however, it may be a fundamentally new challenge.

5 Methodology II: Developmental assessment and implementation prospects

Following our cost and climate assessment of the option, developmental and implementation analyses should then be undertaken – as is done for national studies. In the case of the former – that is, looking at the extent to which an option fits with wider development aspirations – a challenge introduced by the fact that we are looking at entities in more than one country is that development aspirations may not be similar. The way in which externalities may be valued differently by different countries' inhabitants is just one set of examples. Once again, some sort of regional aggregation may have to be undertaken.

Turning to prospects for successful implementation, it is here that we believe the regional options pose particular challenges. Because we are looking at how organisations in distinct, independent and nation-sovereign states interact, new challenges arise. This is an issue into which we investigated relatively thoroughly, and the sorts of issues that affect implementation of regional options include:

- desires to preserve sovereignty
  - concerns about relinquishing decision-making (and implementation) powers to another (often supra-national) body
- debates about a 'fair' distribution of costs and benefits
  - arrangements need to be not only efficient, for the region as a whole, but also 'equitable' for its individual members
- concerns about 'power' in the region
  - asymmetries in regional capabilities may, alternatively, encourage or discourage effective regional arrangements
- similarity of cooperating countries
  - particularly in terms of economic, political and social characteristics
- 'orientation' of cooperating countries
  - that is, the extent to which there is some 'natural' or 'already existing' pattern of cooperation – and this could be again in any of economic, political or social areas
- external factors
  - the influence of TNCs, external investors more generally, donors and international organisations

Many of these will be important in the implementation of national mitigation options as well.

6 Methodology III: Integrating regional and national mitigation alternatives

Nevertheless, at the end of these analyses, we hope that we will have some idea as to the relative attractiveness of different regional mitigation options – in terms of net GHGs abated, cost, compatibility with broader developmental goals and prospects for implementation. By itself, however, this set of information does not offer much. Why? Simply because it would be very rare that a region would or should undertake regional mitigation activities in the absence of parallel national ones. Hence, what needs to be undertaken next is a comparison between regional and national alternatives – for it is most probable that the 'best' portfolio, however we define 'best', would consist of a combination of regional and national actions.

We thus need to introduce national mitigation strategies – of the kind that this conference has been exploring over the past couple of days – into our deliberations. So we would first turn to the national mitigation studies that have been prepared for the countries of the region. All of these, of course, may not be available. Though this is not a fundamental challenge to the logic of the analysis, it does suggest that many resources may have to be mobilised to realise this requirement. What may, however, be more of a challenge is ensuring that different national mitigation studies are compatible – just as we wanted to ensure that national baseline estimates were compatible. We want, for example, to ensure that the exchange rates used in each of the studies are the same, that future energy prices are compatible and so on. Obviously, efforts to develop a common methodology for national studies – of the type undertaken within this broader GEF/UNEP project – are to be welcomed here.

We will then want to combine the national and regional options, in order to determine which portfolio of actions will be 'best'. Again, there is nothing that is theoretically impossible about this task, but also once again, we may well see that it is difficult to determine how the different scenarios impact each other. Some impacts will be obvious – for example, the provision of all of a region's electricity by a new hydropower facility proposed in a regional mitigation scenario will obviously cause the national option of fuel switching from coal to gas in power generation to drop out. Such interactions, however, will not always be as clear cut, and may only cause options to be modified. For example, the development of a regional market for an energy efficiency device would affect the costs of those mitigation options that were initially considered in the context of solely a national market.

Nevertheless, we are hoping that, at the end, we will be able to generate some information about the relative attractiveness of regional options – their attractiveness relative to the baseline (that is, in the absence of concern about global climate change) and their attractiveness relative to national mitigation options.

In concluding this section, I should reiterate that this is but one approach. Regional mitigation analysis is at a very early stage in its methodological development; consequently, it is an appropriate time to remind the audience that this project was considered to be a work of research, an exploratory exercise only. Nevertheless, we hope that we have advanced thinking about regional mitigation analysis, at least to some modest extent.

7 Summary

The purpose of this presentation has been to report upon the methodology that has been developed to investigate and analyse potential regional mitigation activities. Given the focus upon 'methodology', much of the discussion is necessarily abstract; it can be substantiated more fully when considered in conjunction with the empirical investigations that will be reported upon in the following papers. Nevertheless, I hope that I have given you some sense of regional climate change mitigation analysis: what it is, what encourages it and how it might be undertaken.

Even before substantial empirical work had been completed, our sense was that two challenges would probably be particularly significant – one directly related to methodology and the other one more closely associated with actual implementation (Mackenzie and Rowlands, 1998). The methodological one follows from what I reviewed in the sixth section of this paper – namely, the integration of national and regional mitigation options. We anticipated that this would prove particularly difficult – given not only the data requirements, but also the complexities associated with national, let alone regional, economies and social systems.

The other one, meanwhile, has also been explored in this paper – namely, the implementation challenges arising from the fact that the mitigation activity is now dependent upon coordinated action among entities in two or more neighbouring countries. Few would probably disagree with the assertion that, all else being equal, a national mitigation option that reduced carbon dioxide emissions by 1 million tonnes at a certain net cost would be preferred to a regional option that achieved the same reductions at the same cost. The factors highlighted in the fifth section of this paper suggest why. What will, therefore, be decisive to the prospects for implementation of regional mitigation options – indeed, any climate change mitigation options – will be the non-climate consequences – that is, those outcomes following from what we have called the 'developmental assessment'. If clearly positive, entities in the region will be motivated to support implementation; while if neutral, or even only marginally positive, 'champions' for the mitigation options will not arise, and the climate goals will inevitably prove difficult to realise. Though often overused, the phrase 'win-win' nevertheless seems to capture the sentiment well. This is a point to which I will return in the panel discussion following the next two presentations.

Indeed, there are other points about the potential of regional mitigation studies to which I will return in the subsequent panel discussion. For now, however, I will conclude this paper, hoping that it has provided an overview of the methodology development to undertake regional climate change mitigation analysis.

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Appendix I – Using the national study to guide the regional study

National	Regional
1) Gather relevant data	**1)** Gather relevant data
2) Construct the reference or baseline scenario	**2)** Construct the reference or baseline scenario
3) Develop the mitigation scenario(s):	**3)** Develop the mitigation scenario(s):
a) identify the options	**a)** identify the options
b) assess the net costs and greenhouse gas (GHG) reduction/absorption potential	**b)** assess the net costs and greenhouse gas (GHG) reduction/absorption potential
c) create a mitigation scenario	**c)** create a mitigation scenario that is based solely on regional activity
	d) create a mitigation scenario by summing national scenarios
	e) integrate c) and d) to create a regional mitigation scenario
4) Macroeconomic assessment	**4)** Macroeconomic assessment
5) Developmental assessment and analysis of implementation issues	**5)** Developmental assessment and analysis of implementation issues

Source: Rowlands (1998a).

Climate Change Mitigation in SADC through Power Pooling

Norbert Nziramasanga, Southern Centre for Energy and Environment, Zimbabwe

1 Introduction

The Power Sector in SADC is the major source of greenhouse gas emissions. Previous work has shown that opportunities for greenhouse gas emission reduction lie mostly in the energy sector. Most win-win options are linked to energy end-use or energy supply.

It is with this background that a project was carried out by UNEP Collaborating Centre on Energy and Environment and Southern Centre to develop methodology for assessment of regional options for climate change mitigation. The project preceded another initiative by Southern Centre in collaboration with regional partners from SADC countries and funded by GTZ. The latter project is still underway and is to identify Options for GHG Mitigation under Power Pooling in Southern Africa. The work by Southern Centre and UCCEE formed a solid methodological basis to allow the Southern Centre project to progress without being stalled by methodological issues.

The following is a brief description of the approach to climate change mitigation under power pooling.

2 Options for GHG Mitigation

The interconnection of national power utilities gives rise to various options for supply side management. The main options to come to mind are peak demand management and more efficient dispatch of power plant. System security improvement that is natural to interconnection also results in avoided operation of the more expensive emergency plant. In most cases emergency plant is fired by fossil fuels. Therefore reduction of the operating hours for this type of plant will reduce emissions of greenhouse gases. A closer analysis of the options will be possible through knowledge of the following.

3 National Load Duration Curves

A load duration curve shows the number of hours per year for which the peak load is equal or less than a specified figure. The curve therefore has a typical characteristic as shown below. The plant that is run to meet the short duration loads is necessarily more expensive because it has to meet capacity and limited energy. In the absence of energy sales the capital recovery of peaking or emergency plant is through demand charges.

If various national load curves are combined there will be a difference in the occurrence of the peak and also an inherent sharing of emergency plant. The operating hours of the plant will therefore increase and result in a lower capacity charge. In the case of the SADC region the systems are mixed hydroelectric and coal fired thermals with large potential for gas and renewable energy.

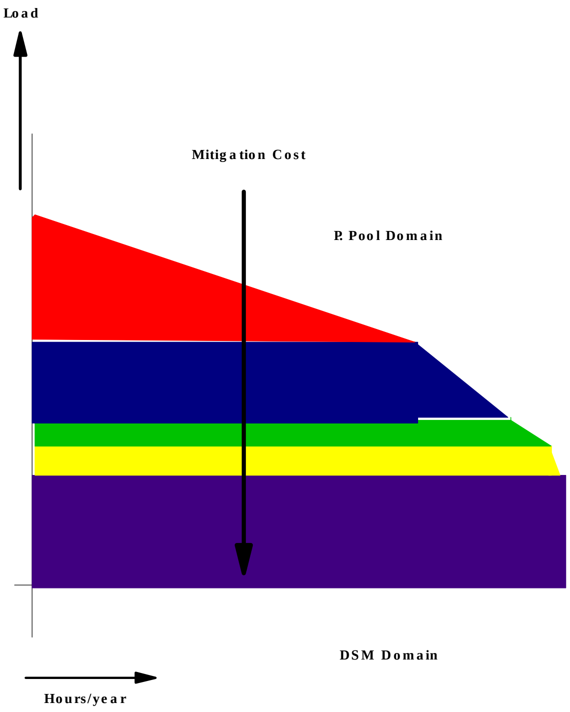

Figure 1 Typical utility load duration curve

4 Hourly, Daily and Seasonal Load Curves

Apart from the time occurrence of a given load it is important to know the load variation pattern on a time basis. If one country has low load when another has a high load there is then the possibility of operating the same peaking plant to meet the loads. In such cases the peaking plant could be lower cost as it would run longer hours. It is also possible to shift peaking load from one country into the make up load of another if the capacity for such a shift is available. In some cases the interruptible load in one country may serve to reduce the production cost in another with energy cost benefits to both parties.

Load diversity is a fundamental principle in interconnected systems that allows for cost reduction and improved system security.

5 Fuel Switching

Given the fuel mix in the regional systems it is possible to shift the operating mode for various plant so as to achieve lower operating cost. An example is the Kariba with storage capacity for hydropower and a low firm energy. Thermal plant could be run instead of the hydro-plant to meet base load. On peaking the hydro-plant would be dispatched to use whatever energy would have been stored. This would avoid operation of less efficient or more expensive peaking plant.

The region has significant gas resources in the form of both natural gas and coal bed methane. Gas turbines have a short lead-time and provide the opportunity for entry into the energy sector by private investors either through cogeneration or grid connected plant. Power Plant connected to the distribution network (imbedded power plant) reduces the need for transmission systems and therefore reduces losses and power transfer cost.

6 Conjunctive Operation

In its simplest form conjunctive operation of hydro-plant is a mode of operation where plant up stream is run first and plant down stream is run last. This enables the utility to release water to outside the system only when it becomes necessary. This mode of operation requires a clear understanding of the hydrology of the system as droughts and seasonal variations have to be accounted for.

The assessment of options is complete only when the operating scenario is tested through network analysis of the resultant system. Both projects mentioned above do not provide for sufficient network analysis for the study, however a study by Purdue University and the regional utilities will give some insight into the technical visibility of the options.

7 Project Methodology

The GTZ supported activity started off by assessing the emissions of greenhouse gases in the power sector in the region. That report is to be published soon. The second phase of the project is underway and will result in a production of the expansions plans for the various utilities and a listing of options for mitigating greenhouse gases in the power sector. It is hoped that follow-up activity will fit the options into an analysis of a development scenario that would meet the development needs of the regional power sector.

The project involves utility partners from the regional power utilities as well as Öko Institute of Germany and SADC TAU. The project has been presented to the SADC Energy ministers who now await results of the study.

Regional Transport Sector Mitigation Options

Peter Zhou, EECG Consultants, Gaborone, Botswana

1 Introduction

The rationale for conducting climate change mitigation studies in the transport sector is on the premise that

- The transport sector is the second largest consumer of fossil fuels in the region.
- The regional transport sector is an area with high opportunity for infrastructural development under UNFCCC financial mechanism.
- The regional transport sector is crucial in the SADC region for trade and coupled with the Trade Protocol will play a major role in development hence the need to make it efficient in terms of energy demand and provision of services.
- The sector offers many mitigation options but with a challenge to evaluate their energy saving and GHG saving potential and yet there is need to quantify possible emission reduction for possible future emission trading. This is also a sector with potential to qualify for financing through Clean Development Mechanism (CDM) recently stipulated in the Kyoto Protocol.

2 Approach

This is a first cut mitigation analysis presenting a challenge for future refinement

The GHG baseline is analysed at regional level by summing up the national transport GHG baselines considering the fuel shares in each country. The proportions of transport fuels for the overall SADC region, excluding Mauritius are presented in Fig 1.

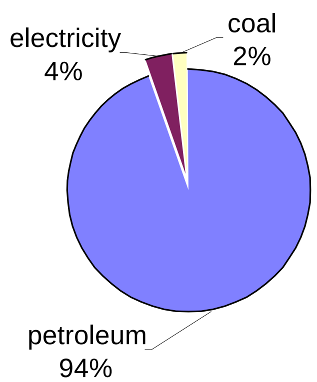

Figure 1 ***Share of transport energy fuels/source in SAR***

Energy consumption levels in the transport sector are varied in the SADC countries but averaged 11.5% of the total energy consumption in 1990 (Zhou, 1997). Petroleum products contributed 94.6% to transport energy in the same year. Five of the eleven SAR countries completely depended on petroleum products for their transport energy in the same year. The rest is provided by coal (1.6%) and then electricity (3.8%) (Fig 1). Both coal and electricity are used in the railway traction but in SAR the electricity is also derived from coal-fired power stations. South Africa also derives part of its petroleum products from coal.
The average regional per capita transport energy was 3519MJ but exceeded 4000MJ in the Middle income countries of South Africa (12466MJ), Botswana (6552MJ), Swaziland (6158MJ) and Namibia (4207MJ). South Africa contributed 81% of the region's transport energy in 1990 (Zhou, 1997).

The future transport energy demand for each country were derived from a per capita transport energy vs. per capita GDP relationship (equation 1) also depicted by Fig 2 below.

$E_t = 701.82 + 2.28*GDP + 0.000609*GDP^2$…………..1

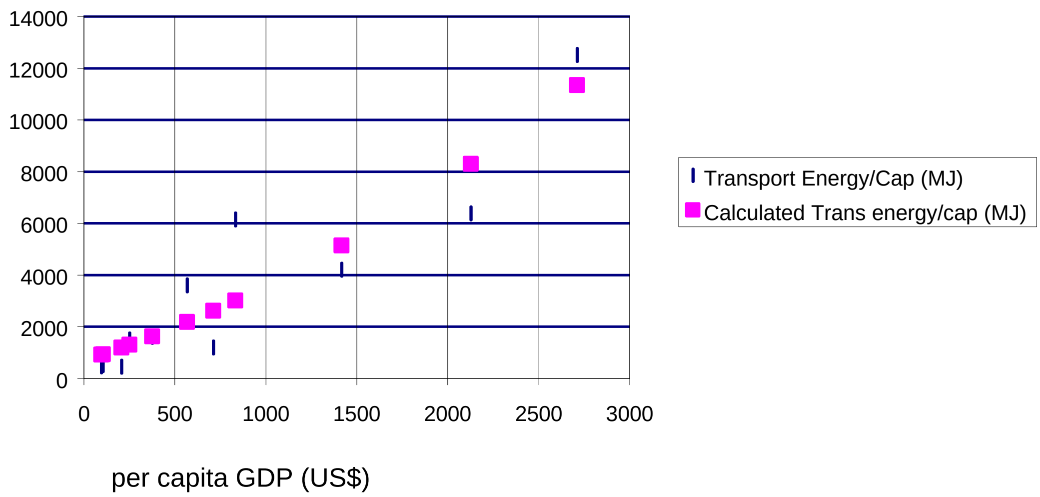

Fig. 2 Transport energy-GDP dependent scenario

Equation 1 was tested with Mauritius data which had a steady historical transport energy consumption and there was a good agreement between observed and calculated energy for the data between 1984 and 1992 (Fig 3) although the formula gives slightly higher figures than the observed energy consumption.

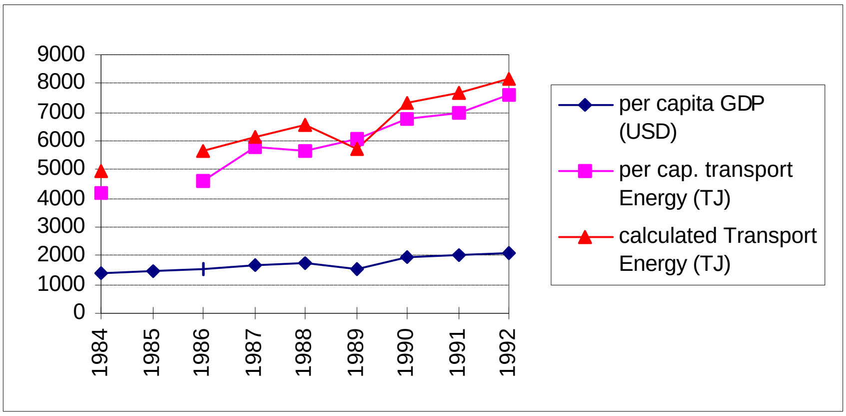

Fig. 3 Observed and calculated per capita transport energy versus per capita GDP for Mauritius

The long term GDP growth rates for the SAR countries determined by World bank- Industry and Energy (1990) were used to project transport energy to 2010, 2030 and 2050 (Table 1). The GDP growth rates were however adjusted to cater for possible long-term effects in the economies of the region.

Table 1 – Actual and projected transportation-related energy demand levels for southern African countries, 1990, 2010, 2030 and 2050. Sources: SADC (1990); Directorate of Roads (1995); and author's estimates.

Country	Actual transportation-related energy demand, 1990 (TJ)	Projected transportation-related energy demand, 2010 (TJ)	Projected transportation-related energy demand, 2030 (TJ)	Projected transportation-related energy demand, 2050 (TJ)
Angola	11,960	67,594	135,708	227,537
Botswana	8,306	26,466	58,739	82,032
Lesotho	2,664	3,983	5,975	7,754
Malawi	4,013	18,334	28,935	40,982
Mozambique	7,332	30,200	56,185	83,632
Namibia	7,573	15,182	22,517	30,587
South Africa	472,004	830,187	1,480,279	2,069,979
Swaziland	4,926	4,757	7,786	10,487
Tanzania	14,032	46,502	70,970	95,586
Zambia	13,579	21,139	31,411	42,306
Zimbabwe	34,988	37,731	60,714	81,773
Regional total	581,377	1,102,075	1,959,220	2,772,654

The advantage of using both population and GDP for long term projection is that these parameters tend to be stable (in the absence of sudden disruptions e.g. of war) over a long period. This approach allows estimation of projected transport energy demand in the absence of comprehensive long term national or region transport plans. The current national transport plans have the same period as the national plans and in the region National Development

Plans do not exceed 10 years. Some countries have initiated national Development Visions, which extend to about 20 years. In these visions, sectoral, including transport, GDP growth rates are estimated. Similar growth rates have been incorporated (where Visions exist) to make projections to 2050.

The constraint is that for some of the countries that had turmoil in the last two decades, GDP growth rates were erratic and very low compared to population growth rate. This situation tends to result in future lower transport energy than at present. The GDP growth rates for the various countries have thus been modified to be representative of a realistic case in the long-term scenarios.

The rationale for basing future transport energy demand on per capita income is because it requires a decent income to afford motorised (thus polluting) transport. The population growth component is also incorporated in the per capita transport energy and GDP. The constraint of this scenario is in getting reliable long-term GDP growth rates in a region whose economy has been interrupted by turmoil in the last two decades.

The CO_2 equivalent emissions determined for SAR for 2010, 2030 and 2050 using this approach are 101 Mt, 180 Mt and 254 Mt respectively. These figures exclude emissions from conversion of coal to petroleum products for South Africa.

3 Climate Change Mitigation Analysis

The presentation examined six possible CC mitigation options which may shed light on the potential for GHG reduction in the transport sector along transport corridors of the region. These GHG reduction measures fall within the following categories.

- moving from road to rail freight;
- electric trains replacing diesel trains;
- fuel substitution from gasoline to compressed natural gas;
- paving and maintaining the regional road network;
- Petroleum pipeline replacing rail and road freight;

The analysis for each possible mitigation option examines its baseline character, possible modifications as part of the mitigation scenario and its implementation aspects in the context of the region. Both estimates of GHG reduction levels and costs were made for each mitigation option. Costs of some options may be difficult to get hence, where data limits quantitative analysis, a description of possibilities has been made excluding costs.

4 Climate Change Mitigation Option Assessment

Shifting road to Rail freight

Data on road transport is scarce in the region even for corridor transport. The bulk of corridor transport is shared between rail and road and we know that in 1993 rail transported 80% of the dry cargo. The Beira corridor was here considered for this option involving only dry cargo.

Between 60 and 70 per cent of goods travelling through the Mozambican port of Beira have either come from, or are heading to, Zimbabwe. The length of this route, from Beira (in Mozambique) to Mutare (in Zimbabwe), is approximately 345 kilometres. The mass of dry cargo carried on this route during recent years has been as follows: 1,400 kilotonnes (in

1992), 1,562 kilotonnes (1993) and 1,290 kilotonnes (1994) thus the growth in total cargo or dry cargo on the Beira Corridor does not seem to have a specific trend.

Although fluctuations can be partially explained by the presence or absence of drought in the region – which in turn influences the amount of drought relief food required, as well as the quantity of agricultural goods exported – present regional trends in trade, as well as developments themselves within the corridor, suggest that traffic levels will grow in the future as determined by both population and GDP growth.

For future scenarios, both population and GDP were used to determine the traffic levels. Dry cargo per capita and per GDP gave a possible scenario on dry cargo growth to 2050. The population and GDP growth rates estimated for Zimbabwe were adopted since this corridor mainly carries Zimbabwe goods/cargo.

For the baseline, the share of rail to road of 85% to 15% in 2050 is assumed based in past trends in shares. In the Mitigation Scenario all long distance haulage of dry cargo is by rail (100%).

The rail and road equipment required in 2050 and the CO_2 equivalent emissions reduction potential were determined on a spreadsheet using the Greenhouse Gas Abatement Costing Model (GACMO) developed by the UNEP Centre in Denmark.

Energy intensity of freight trains (50-80% load factor) and heavy trucks (60-110% load factor) were given in IPCC 1995 as 0.4- 1.0 MJ/t-km and 0.6-1.0 t-km respectively.

A parallel study done for an AFREPREN study to 2020 was also presented involving the Harare-Beit Bridge-Johannesburg; Lusaka-Beit Bridge-Johannesburg and Shaba-Zaire-Lusaka-Beit Bridge- Johannesburg and Table 2 and Fig 3 show the GHG reduction potential and costs of reducing a ton of CO_2 equivalent emissions.

Table 2 GHG Emission Reduction Potential of Road to Rail Mass Transit system Option along the RSA-Ports Route for Zimbabwe, Zambia and Zaire.

Route	baseline GHG* (t)	Intervention GHG (t)	Reduction-intervention (t)	cost/t reduced US$	Aggressive GHG (t)	Reduction Aggressive (t)	Cost /t reduced
HRE-JHB 2005	**420638**	370396	**50241**	**406.89**	269913	**150725**	**49.20**
2020	**615364**	321363	**294001**	**-36.98**	174362	**441002**	**-67.87**
LUS-JHB 2005	**33785**	29829	**3956**	**10463.00**	21916	**11869**	**3383.00**
2020	**39379**	20934	**18445**	**2134.20**	11711	**27668**	**1370.64**
SHABA_JHB- 2005	**34355**	26237	**8118**	**131.81**	22179	**12176**	**29.64**
2020	**41602**	21942	**19660**	**-47.82**	12112	**29490**	**-90.112**
TOTAL 2005	**488778**	426462 (87%)	**62315**	**1009.46****	314008 (64%)	**174770**	**274.24****
TOTAL 2020	**696345**	364239 (52%)	**332106**	**82.96****	198185 (28%)	**498160**	**10.71****

**GHG = CO_2 equivalent emissions (CO_2, CH_4 & N_2O)*
*** Weighted cost/t of reducing Co2 equiv. For the three countries' freight.*

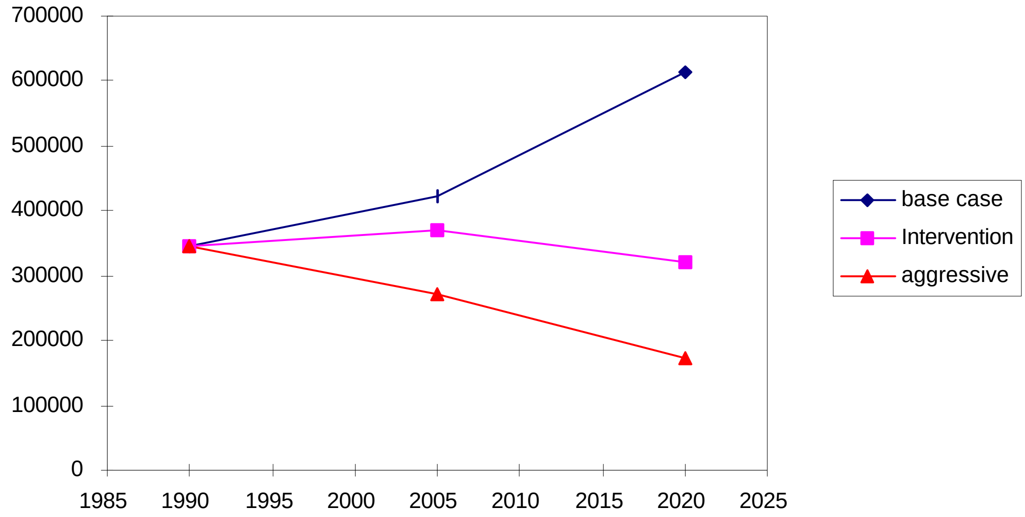

Figure 3 Harare-Johannesburg corridor GHG emissions- baseline, intervention and aggressive scenarios for the Base Case.

Hydro-based electric rail along corridors displacing diesel trains

This mitigation option assumes the hydrophilic scenario in the power sector such that power used for trains originates from hydropower source. If the electricity is derived from coal then the GHG emission savings will be minute or absent.

The option was again treated for the Beira Corridor with distances of 602 km. The electric trains are to replace diesel trains for cargoes (t-km) estimated for 2050. Energy intensity for fully laden electric and diesel trains are 0.25-0.29 MJ/t-km and 0.19 to 0.27 MJ/t-km respectively (ETSU, 1995). There is no actual energy saving as such but energy/fuel type allows emission savings. The added incentive for implementing this measure is the savings on diesel procured from outside the region and the elimination of related air pollution caused by diesel trains. The capacity of an electric train is also larger (826-1281 tonnes) compared to diesel (705-1135 tonnes) ETSU, 1995. By assuming these capacities it is possible to estimate the number of trains or times a train would travel in 2050 to carry the estimated cargo and hence the required energy (either electricity or diesel).

Fuel Substitution for low-carbon transport fuels e.g. substituting natural gas for gasoline.

This option is aimed at gasoline vehicles to be modified or made to use compressed natural gas (CNG). This becomes feasible on the premise that the region has vast reserves of natural gas (1.14 trillion m^3. IPCC 1995 shows that it cost New Zealand about US$750 to modify a gasoline car to use CNG but also required grants and subsidies to make it work in the light of low petroleum prices. This option would work when coupled with preferential fuel taxes or carbon taxes. It is estimated that considering a fuel cycle, CNG can save 10-30% emissions than gasoline.

In this study we assumed 1% of RSA gasoline vehicles in 2050 shifting to CNG. In the same regard the annual energy requirement to replace gasoline. The CNG supply system is catered for in the price of CNG of 0.18-. 24 US$/litre of gasoline equivalent compared to 0.26 US$/litre for gasoline (IPCC, 1995).

Improvements in infrastructure e.g. paving of roads and maintenance

The pavement of roads can result in as much as 50% energy savings (Botswana Transport Plan, 1983) per vehicle as compared to unpaved road. The measure would entail proper maintenance of paved roads and paving unpaved roads in the region. Under the current corridor rehabilitation programmes, SADC through SATCC has been involved in prioritising trunk routes to be upgraded. In the same manner, the mitigation option would be regional in the sense that trunk routes and feeder roads important to regional transport systems would get first priority. In this respect it will not be easy estimating the actual GHG emissions reduced because the number of vehicles in those sections of unpaved roads are not known and it is not known how they will increase to 2050. An estimation could be made on the assumption that 20% of the vehicles in the region travel 30% of their 20 000 km annual distance in gravel road. If this is the case, then the energy differential could be worked out. In actual sense, the saving could be higher.

A GEF project would involve training the region in road maintenance and building of durable paved roads. Such activities are partly being implemented by donor countries e.g. Germany is conducting a training course for 6 months to selected regional engineers (CDG personal communication)

Petroleum pipeline for transporting petroleum products.

This has been considered for replacing rail and road petroleum freight transport with a pipeline between Pretoria and Gaborone considering the fuel demand in 2050.

The potential GHG reduction by each of the evaluated option are presented in Table 3

Table 3 Potential GHG (CO_2 equivalent) emissions reduction in 2050.

GHG Mitigation Option	GHG Reduction tons /yr.	Cost US$/ton of CO_2 equiv.
Road to rail-Mutare-Beira	15 000	8.58
Electrifying Rail-Mutare-Beira	32 000	38.28
Gasoline to CNG-1% of RSV's cars	120 000	1.37
Pipeline-Pretoria to Gaborone	57 000	63.41

Policy Measures. For any of the mitigation opportunities to be realised, regional management bodies like SATCC and governments have to incorporate the energy concern in their transport operations planning. Energy is a major recurring expense in all the transport modes and hence should be one area for cost cutting. This measure would also result in reduced air pollution and GHG emissions.

Institutional and Legal Aspects. Whether, the policy measures are of regulatory or of incentive nature, institutions have to be in place to monitor the performance of the sector.

In the SADC region, the major transport systems are presently under the control of governments (central or parastatals). The government has failed to retain experienced staff due to unattractive packages, and such manpower has moved to the private sector. The effective institutional arrangements would be therefore that government stipulates the policy measures but the private sector is also involved in ensuring the functionality of the various organs of the transport sector.

Similarly the legal framework has to exist to ensure regulatory measures are implemented. The necessary institutions are therefore required for effective enforcing of the legal aspects. Law enforcement has always been in the hands of government, hence to make it effective, better remuneration packages and operational facilities for such institutions should be provided.

Financing. Various mechanisms for financing improvements in the transport sector efficiency are available. The conventional ones have been the *Official Development Assistance (ODA)* and the *Multilateral Lending*, the latter involving the International Banks. Lately, the UNFCCC has indicated possible funding for developing countries, as a means to assist them in meeting their global efforts to combat climate change. The much-talked-about mechanisms are *Joint Implementation* and the *Global Environmental Facility (GEF) Incremental Cost* and now recently the *Clean Development Mechanism*.

Both JI and CDM have the potential to fund large transport infrastructure while GEF may only be available for removal of barriers to implementation of GHG reduction projects. Both JI and CDM may even replace the present day ODA since in the former donor countries will benefit from both GHG reduction credits and creating markets and jobs for their own companies. ODA had mainly creation of markets and jobs as the benefits to donor countries.

Certain in-house keeping, require effective utilisation of locally available financial resources or local fund-raising to meet a new investment. National insurance and banking institutions sometimes have enough resources to meet certain national project budgets. It would then be better to meet all local costs from internal or regional borrowing and only borrow the foreign currency component from the International Banks. In this regard the sector could exploit cross-border investments (e.g. from RSA and Mauritius firms), public and private sector partnerships and private sector initiatives in form of BOO, BOT and BOOT.

In addressing efficiency gaps in the transport sector, it is therefore important to match mitigation options with appropriate financing mechanisms.

Regional Cooperation and Climate Change Strategies

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1 Background

The recent political developments around Climate Change have greatly increased the complexity of operations in the sustainable development area. The finalisation of the Kyoto Protocol, along with the future enabling of emissions trading, the Clean Development Mechanism (CDM)) and Joint Implementation (JI) present numerous opportunities for developed nations to reduce emissions and for developing nations both to optimise emission increases and to level the development playing field. The question is what opportunities lie ahead for African nations in this global equation?

One thing is certain, Africa, with its 3% contribution to global greenhouse gas emissions, is hardly likely to be viewed as a prime candidate for JI or the emission reduction component of the CDM. In fact, even as African economies grow, emissions are likely to increase at a minimal rate compared to increases expected of the larger developing nations such as China and India. Even the largest African emitter, South Africa, projects small increases of 2-3% - small when compared to China's projection of increasing coal combustion from 1.2 billion tons in 1997, to 1.46 billion tons by 2000 (21% in 3 years). African nations should therefore not focus on how to reduce emissions, or concern themselves with the overrated threat of pressures to reduce emissions. Far greater climate change threats need attention, and likewise far greater climate change opportunities await us. In this sense, I summarise some of the major threats, opportunities and potential mechanisms to avoid the former and exploit the latter via regional cooperation.

2 Threats

2.1 Negative impacts of climate change

African nations, especially Southern African nations are extremely vulnerable to potential negative impacts of climate change e.g. increased drought and floods, changing pest and disease patterns. These negative impacts are going to hit us long before developed nations' emission reduction has an impact. As such it is critical that we develop strategies to adapt to these impacts. Such strategies can include:

- Strengthening the regional power infrastructure to increase fuel flexibility
- Agricultural cooperation
- Regional electrification to reduce fuel wood dependency
- Cooperation in regional water supply

2.2 Knock-on economic impacts

The knock-on economic impacts of actions taken elsewhere in the world can be severe, e.g. the increased cost of imports due to higher global energy costs, replacement costs of HFCs and SF_6 due to level of availability, loss of jobs in the fossil fuel sectors due to reduced exports, etc.

It is important to anticipate and model these impacts economically so that appropriate response strategies can be developed. In particular the Clean Development Mechanism presents opportunities to source adaptation funds in this area.

3 Opportunities

African nations are uniquely positioned to apply existing and planned mechanisms and instruments under climate change. Joint Implementation, the CDM and the Global Environmental facility all present opportunities to manage our emission increases as our economies grow, whilst at the same time getting others to fund such growth – truly a "win-win" opportunity. Specific projects which could benefit from regional synergism, whilst contributing to regional sustainable development include:

- regional electrification – rural and urban, with a renewable focus in rural areas
- Southern African power pool
- Power plant energy efficiency improvements
- Road and rail transport upgrades
- Sustainable utilisation of biomass
- Distributed power utilities based on stand alone technologies, including small-scale nuclear (the Pebble Bed reactor)
- Energisation programmes

Many of the above projects have a strong utility focus, and a such may well form out of institutions such as the recently formed Power Institute of East and Southern Africa (PIESA).

The above-mentioned projects are all feasible and could be viable, especially if funded under the mechanism created under the UNFCCC and the Kyoto Protocol.

It is clear that regional cooperation in "win-win" areas such as these can create the foundation for the much vaunted African Renaissance, whilst at the same time enabling the mitigation of greenhouse gas emissions.