A Rapid Assessment of a National Energy and Low Carbon Path for Rwanda

Project Number CNTR 200707787

Submission to National Advisory Committee for comment

May 2009

Key Policy Summary and Recommendations

In advance of the Kigali Finance Minister's Meeting for Development, this study presents a rapid assessment of a National Energy and Low Carbon Path for Rwanda. It has been undertaken as part of a UK DFID funded study on the *Economics of Climate Change in Rwanda* by the Stockholm Environment Institute, with input from the Smith School of Enterprise and the Environment.

The study has compiled indicative emissions projections for Rwanda, which are consistent with the objectives in the Vision document and other strategic national planning documents. It has then considered the potential for low carbon development and assessed different national emission indicators and potential targets. Finally, it has considered the potential mechanisms that might emerge from the forthcoming negotiations, and the potential positions and implications for Rwanda.

We highlight that the analysis here has been undertaken very rapidly, and that further analysis is warranted. The findings are summarised below.

- Because of its location, availability of resources, and socio-economic conditions, the study concludes that there are significant economic benefits for Rwanda in following a low carbon development path, as well as large environmental and social benefits. A low carbon pathway is strongly in Rwanda's self interest, and would also provide potential extra investment from carbon financing.

- In many areas, Rwanda is already initiating measures and policies that are consistent with low carbon development, and these provide practical demonstrations of the benefits of such policy. The most obvious progress is the electricity sector, where carbon intensity is predicted to fall with planned policy proposals, as well as reducing energy costs and improving the environment. There has also been progress in more efficient use of biomass in the domestic sector, which has wider environmental and social benefits.

- The key aim for Rwanda is to continue this switch to a lower carbon pathway, to further realise these benefits, and to maximise the potential for the flow of carbon credits under existing and future mechanisms. To advance this, the study has considered a number of national level indicators, which might have potential in relation to future mechanisms.

- The study finds that total national emissions are currently very low in Rwanda, and due to forest sequestion, Rwanda is currently a net sink of GHG emissions. Consistent with economic development, emissions are projected to rise significantly across all sectors. Energy related emissions are currently low, but are increasing, primarily due to transport growth. Total national level emissions are dominated by the agricultural sector and are also projected to grow rapidly, such that Rwanda will become a net emitter in a few years time.

- However, there are low carbon opportunities across all sectors, and many of these offer low cost and no regret measures, particularly if carbon financing can be secured. These options also provide important co-benefits. There is also a need for a longer term perspective to prevent Rwanda getting locked into a high emission path, so as to allow maximum potential for capturing financing opportunities in the future. While it could be possible to assess the potential reductions from a business as usual case (e.g. a national level reduction), the lack of information means that a detailed assessment of a realistic baseline and potential reductions cannot be made at present. This cautions against any current proposals for national level baselines or national caps or reductions.

- Rwanda has very low energy related per capita emissions, at around 0.2 tCO_2 per person. These are amongst the lowest in the world. However, levels are much higher when all GHG emissions and land-use changes are included, estimated at 0.65 tCO_2 per person (excluding forestry sinks). Per capita emissions are projected to rise to 0.3 tCO_2 per person (energy only) and 0.9 tCO_2 per person for all GHG including land use by 2020. This is still below the indicative long-term global average targets that have been advocated by some commentators (of 2 tCO_2/per person), but there is currently no scope for formal negotiations or mechanisms to be based around per capita values.

- Rwanda also has fairly low carbon intensity when energy related emissions only are considered (478 tCO_2/\$Mill GDP), though again these rise significantly when GHG emissions from agriculture and land-use change are included to 1864 tCO_2/\$Mill GDP (excluding forestry sinks). Carbon intensity is projected to decrease slightly by 2020, though there is very high uncertainty in this forecast, due to the agricultural sector projections. However, Rwanda does not have a large industrial or energy base, and so intensity targets do not really make sense: agricultural emissions dominate carbon emissions and the future projections and intensity in the agricultural sector are very unclear. Energy emissions are dominated by transport, which is a difficult sector to tackle with intensity goals. Therefore any specific intensity plans would be highly uncertain.

- The study has also considered what type of mechanisms may emerge from the forthcoming negotiations, and whether adopting some form of target or cap (from the list above) would be advantageous. There is still very large uncertainty on what exactly will emerge from the future negotiations, though programmatic CDM is likely to be progressed in the near future.

- In the context of the Copenhagen, there has been discussion of national level mechanisms. The proposal that has gained the most ground is a proposal for a Registry of Nationally Appropriate Mitigation Actions (NAMAs). It is unclear at this point what precise functions this registry will fulfil, or indeed what actions, and under what conditions, will qualify for registration. Nonetheless, it is likely that the registry will provide recognition for NAMAs and match them with appropriate financial, technological and capacity-building support. It is also likely, as the EU and US have proposed, that developing countries will be required to develop national low carbon development plans within which NAMAs can be located. LDCs will likely be provided with greater flexibility and financial assistance in developing these plans.

- There are also voluntary carbon market opportunities which could offer more flexibility and may be suitable for Rwanda. Indeed, there are already ongoing projects in the country (sustainable, low-carbon, agro-forestry and land-use management). These projects have strong adaptation-mitigation linkages, in addition to sustainable livelihoods benefits.

- Finally, the study has considered the potential impacts and economic costs of climate change to Rwanda, and the potential adaptation needs to address these. A downscaling of current African adaptation financing concludes that the current estimates of adaptation needs would involve potentially large finance flows to Africa and to a country such as Rwanda.

Based on the study findings, we make the following recommendations.

1. The study finds very real economic, environmental and social benefits to Rwanda from adopting a low carbon development path, and we would recommend a strong continued commitment to such a policy. Rwanda is already advancing low carbon initiatives in many areas and provides a pioneering example of the practicality and benefits of such policy.

2. While it would be possible to set some form of target as a further political commitment to this low carbon pathway at the Kigali meeting, <u>we do not recommend this at the current time</u>. The primary reason for Rwanda to set a target is to maximise the potential for carbon credits and investment flows under current or future mechanisms. Announcing an early target in advance of the outcomes of the negotiations is likely to constrain future options for Rwanda.

3. This point is further reinforced by the current uncertainty around Rwanda's national emissions and growth path. Based on this very quick study, we do not believe it is possible to estimate the future emissions baseline - and the carbon reduction potential for Rwanda - to a degree of confidence that would allow a political target and announcement.

4. While some reforms or even new mechanisms will be more favorable for Rwanda than others, we do not believe that Rwanda (on its own) can introduce or shape the future mechanism that will emerge - and is more likely to be successful in gaining advantageous changes as part of a common African position. We would encourage engagement with the African Group of negotiators towards this, as well as collaborative regional action.

5. There is a large need for adaptation finance for Africa and Rwanda, and entitlement to substantial funds through the Adaptation Fund must be assured. This will be helped through a common negotiating position. However, accessing any funds will require the development of effective mechanisms and institutions within Rwanda. There is a need to consider the linkages between adaptation and low carbon pathways, and exploit the opportunities that arise from considering them together.

6. Following from the points above, we believe it would be extremely beneficial for Rwanda to undertake an early and detailed assessment of a low carbon strategy and adaptation assessment before Copenhagen. This would consider the analytical underpinnings that will feed into a national low carbon development plan. It would also be advisable for Rwanda to strengthen its capacity to develop and implement proposals for specific NAMAs and adaptation funding that might usefully be undertaken in Rwanda. Taking this action would address the issues raised above. More importantly it would give Rwanda a first mover advantage to act quickly, and to seek funding for this plan, through whatever negotiating positions and mechanisms emerge.

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Paul Watkiss, Steve Pye and Jillian Dyszynski. The document also includes a section from Daniel Bodansky, Visiting Fellow, Smith School of Enterprise and Environment

15/5/2009.

Briefing note produced as part of the DFID funded study on the Economics of Climate change in East Africa.

It is highlighted that this document has been prepared extremely quickly, and thus the numbers within it should only be treated as indicative.

Rwanda is currently developing its Second National Communication under the UNFCCC; draft estimates for the energy and agriculture sector have been made available for this report but should be considered provisional

Title	A Rapid Assessment of a National Energy and Low Carbon Path for Rwanda: Key Messages
Client	Department for International Development (DFID) and DANIDA
Client contract No	Project Number CNTR 200707787
DEW Point Ref	DEW 7475
Contact and correspondence	DEW Point, The Old Mill • Blisworth Hill Barns • Stoke Road • Blisworth • Northampton, • NN7 3DB • UK TEL: +44 (0)1604 858257 FAX: +44 (0)1604 858305 e-mail: helpdesk@dewpoint.org.uk www.dewpoint.org.uk
Authors	Paul Watkiss (Email: paul_watkiss@btinternet.com, Tel: +44 797 104 9682) Steve Pye, Jillian Dyszynsk (SEI), Daniel Bodansky
Amendment record	Version 2 Date:
	Key Messages May 2009
Task Manager	Paul Watkiss
Quality Assurance	Tom Downing

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[1] Consortium comprises Harewelle International Limited, NR International, Practical Action Consulting, Cranfield University and AEA Energy and Environment.

1) Introduction

In advance of the Kigali Finance Minister's Meeting for Development, this study presents a rapid assessment of a National Energy and Low Carbon Path for Rwanda. It has been undertaken as part of the UK DFID funded study on the *Economics of Climate Change in Rwanda* by the Stockholm Environment Institute, with additional input from the Smith School of Enterprise and the Environment. The details of the DFID funded project are provided in the box below.

The DFID study '*Economic Impacts of Climate Change in Burundi, Kenya and Rwanda* has a number of key aims, as set out in the Terms of Reference:

- To assess the potential impacts of climate change on key sectors on the economy and non-market sectors (such as health) so countries can understand what is at stake for them.
- To stimulate government, private sector and civil society actions to develop and implement policies to adapt to and mitigate (depending on international incentives) climate change.
- To provide an evidence base to inform and guide government's negotiation position for COP 15.

It also has a number of indirect aims:

- To alert public opinion to the urgency of the climate change challenge, and its potential socio-economic impacts
- To stimulate national debate on the economic costs and benefits of a range of possible actions on adaptation and mitigation
- To encourage a regional approach to negotiations and promoting dialogue on shared challenges
- To build local capacity to analyse the challenges
- To highlight areas where further work is required to understand impacts and policy responses to climate change

More specifically, the study is to include at a country level, i.e. for Rwanda:

- *Impact Assessment*: substantive analysis to develop a comprehensive and quantified assessment of the economic impacts of climate change. The impact analysis should emphasise climate effects both on Rwanda's economy and prospects for growth, as well as on the poorer and more vulnerable sections of society (specifically via the MDGs).
- *Costed Options for Mitigation and Adaptation*: analysis of the costs and benefits of climate change mitigation and adaptation in the short, medium and long term, including an assessment of regional interdependence and its consequential multiplier effect. (Time horizons may be informed by country planning processes, e.g. 2020, 2025 and 2030. For adaptation use of the MDG 2015 target may be helpful).

While the project intended to undertake a low carbon analysis, this has been brought forward in the study, in order to provide for information to feed into the Kigali Finance for Development Meeting (of African Finance Ministers) in late May. This document therefore provides a rapid analysis, for input to the DFID study Rwanda Country Advisor Committee for comment.

The document is set out as follows.

Section 2 presents the energy and emissions situation for Rwanda

Section 3 discusses potential carbon targets for Rwanda.

Section 4 outlines the potential impacts of climate change in Rwanda and discusses adaptation.

Section 5 outline the possible negotiation position and access to carbon finance.

Section 6 presents recommendations.

<u>It is highlighted that this document has been prepared extremely quickly, and thus the numbers within it should only be treated as indicative.</u>

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2) Energy and Emission Projections

What are current emissions in Rwanda?

Due to sequestration of CO_2 by forests, Rwanda is currently a net sink of GHG emissions. The energy and agriculture sectors are the largest emitters of GHGs in Rwanda, noting that CO_2 emissions arising from burning biomass are not included in IPCC inventories (see below, Fig 1 and 2).

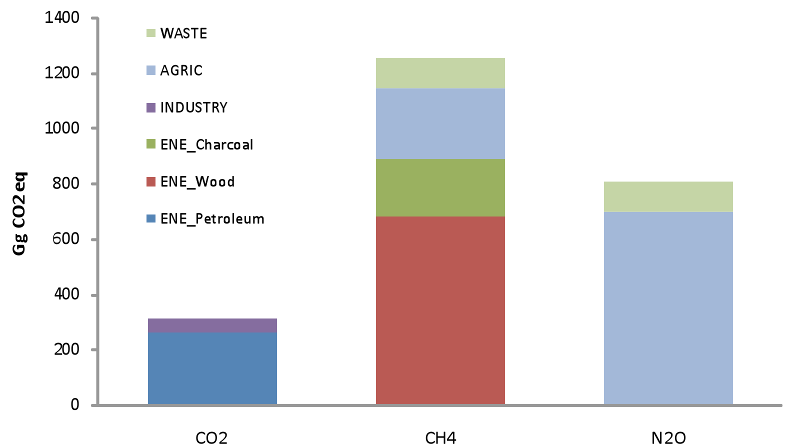


Figure 1. GHG emissions in 2002 by GHG (excluding LUCF)

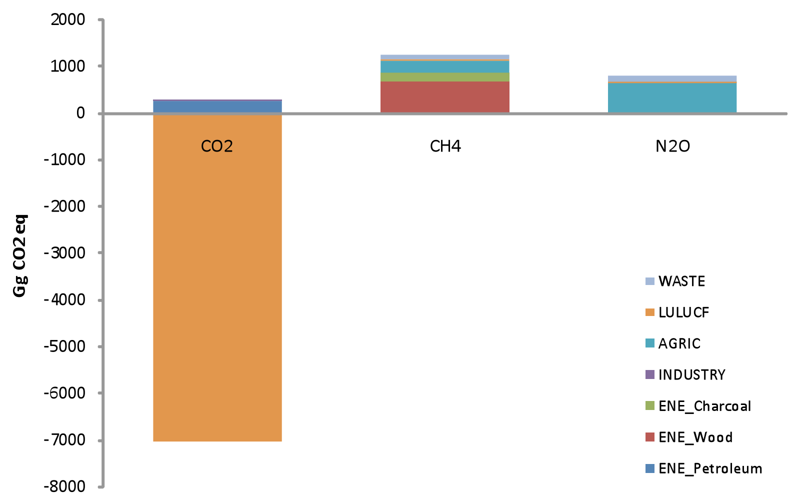


Figure 2. GHG emissions in 2002 by GHG (including LUCF)

However, energy related emissions are rising. Energy emissions are increasing (2nd Nat. Com.) with strong increases in petroleum related emissions (up 40% from 2006 compared to 2003).

What are current and projected emissions for the Electricity Sector?

The study has estimated (very approximately) future electricity generation and emissions, using demand forecasts from Vision 2020, and a project-by-project basis, to assess existing and planned capacity. This includes the Lake Kivu project, planned hydro (Rukarara and Nyabarongo), greater access to regional hydro projects (Rusizi III / IV and Rusumo) and removal of rented diesel once the Jabana Heavy Fuel Oil (HFO) plant is online in 2009. An estimate has also been made for later extensions of the Lake Kivu project up to a total of 200 MW (100 MW in 2015, though this may come on line with 50 MW in 2014, with the rest a few years later). Electricity forecasts are shown in Fig. 3 below. Demand (the forecast red line) increases in line with vision objectives. Note values have not been cross checked against all other sources (notably against the Rwanda tariff study, which has slightly different GWh values in the period 08-12).

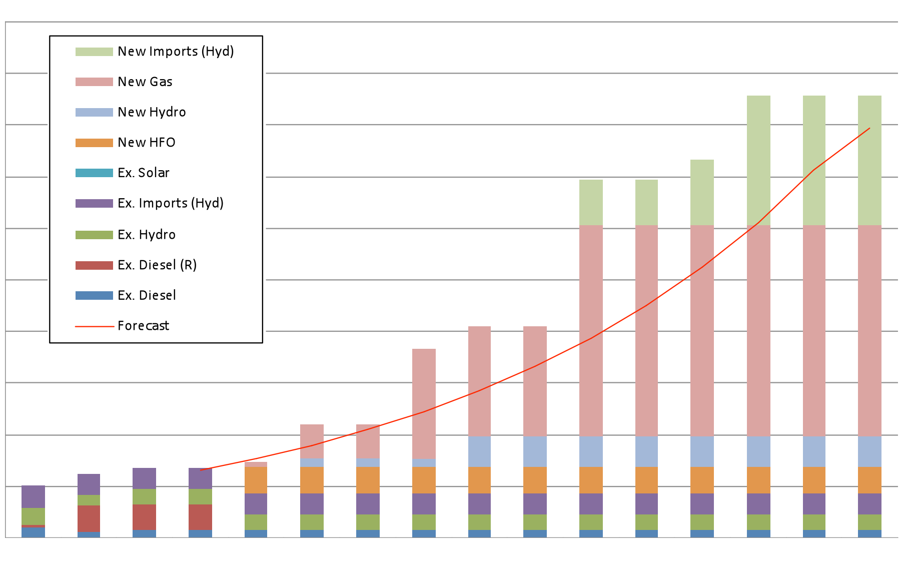


Figure 3. Historic and projected estimates of electricity generation (GWh) in Rwanda, 2005-2020
Primary source: Energy Strategy 2008-2012 (GoR 2009)

Approximate projected estimates of CO_2 emissions from the generation sector are shown below (Fig 4) and show significant absolute increases, due to the increased size of generation (rising supply), and due to the CO_2 from methane generation (using the Lake Kivu resource).

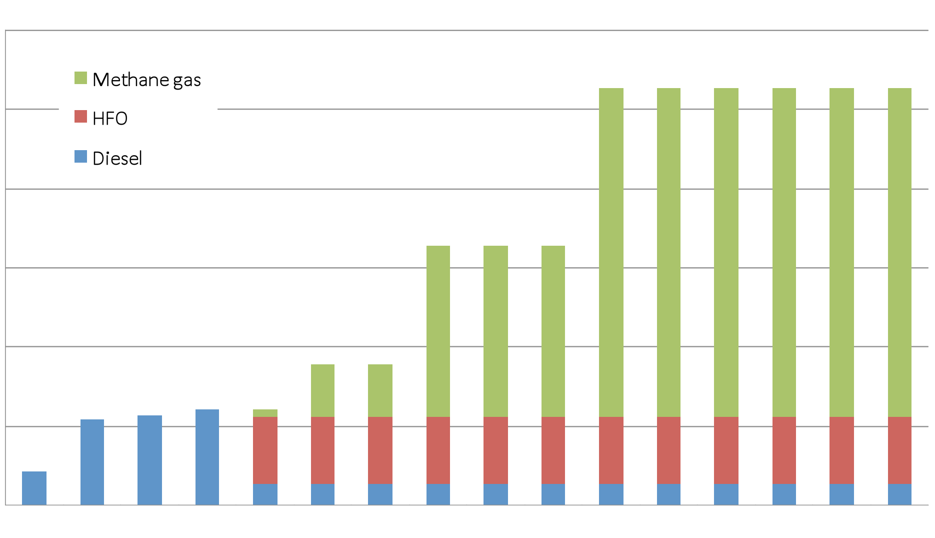


Figure 4. Projected CO_2 emissions from electricity generation in Rwanda (Indicative only)

However, while emissions are rising, the sector is becoming les carbon intensive. Despite the overall increase in emissions, the carbon intensity per unit of generation (grammes of CO_2 per kWh supplied) is falling, thus the Rwandan electricity generation is broadly on a low carbon trajectory. The fall happens as the HFO plant becomes a lower proportion of the overall generation mix, with demand growth met by renewables (hydro) which are zero carbon, and the methane Lake Kivu project, which is medium carbon.

Figure 5. CO_2 intensity from electricity generation in Rwanda. Note forecasts are indicative only.

- The electricity sector (2007 and 2008) had an estimated a carbon intensity of 490 to 530 gCO_2/kWh in recent years of 2006 - 2008 (net, after adjusting for losses). Note the values for 2005 are not typical, due to the lower hydro potential in that year and also lower power production (rationing).

- The 2008 figure is similar to the UK. The intensity in the period 2009 – 2012 drops to around 460 to 475 gCO2/kW to 2014. It potentially falls further with regional hydro coming on line in 2015, to around 430 gCO_2/kWh.

- It falls significantly in 2018 due to greater regional hydro coming on line (to 340 gCO_2/kWh). The 2018 – 2020 value would be a decrease of around 30 - 35% from the 2008 peak. Note that supply and demand have not been matched exactly in the analysis, which accounts for the bumpy trend in carbon intensity and the higher value in 2012. We have also not taken full account of exports; a regional grid could help in utilising any spare capacity.

- However, these predictions are conditional on regional hydro (or other low carbon renewables) coming on line. Moreover, a third phase of Lake Kivu (>200 MW capacity total) would increase emissions upwards, as the carbon intensity of the project is higher than forecast average (probably 450 – 500 gCO_2/kWh).

We highlight that any carbon intensity targets in the electricity sector could be made difficult with a change in the ratio of Lake Kivu: renewables, as greater Kivu capacity is added in future years. We would therefore recommend other zero carbon resources – notably hydro and wind or possibly regional geothermal – are considered in the generation mix, in preference to Lake Kivu. The wind resource in the country is currently being assessed. However, any move to these other renewables may be constrained by the very low costs of generation at Kivu.

In this analysis above, we assume that Lake Kivu is a renewable supply, in that methane in the lake is continually being generated (self generating). However, while the methane itself may be of biomass origin, it may not have been produced from biogenic substrates. Thus for combustion, we assumed CO_2 emissions are treated similar to fossil fuel gas. Note also that we assume that the methane in the lake would not have been emitted from the lake within the conventional time-scales for carbon reporting, thus there is no net effect in reducing the release of methane which has a higher GHG potential. We also assume that CO_2 from the extraction process is re-injected to below 200 metres depth, to prevent short-term release. It is assumed that gas engines are used (not gas turbines).

Lake Kivu[2] has deep waters that contain a very large amount of dissolved CO_2 and methane gas. These are formed from a combination of geological and biological processes (there is some uncertainty, but probably the CO_2 is partly of volcanic origin as well as formed by the decomposition and fermentation of organic material by anaerobic bacteria accumulating in the bottom sediment, whilst the methane is probably generated by fermentation processes and by the reduction of volcanic carbon dioxide by the same bacteria). It is estimated that some 100 to 150 million m^3 of methane are generated annually in the lake, thus it is often referred to as a renewable source of energy. Total gas reserves are around 29 billion m^3 and most of the gas is located at approximately below 270 meters depth, where high-density gradients prevent any mixing phenomena, thus facilitating the gas accumulation. The Kivu project is a combination of a gas extraction, production and processing plant and an onshore gas-fired power plant. Note that the gas extraction process does generate by-products including CO_2 (due to the 80:20 mix of CO_2 to methane). The extraction guidelines require the developers to reinject the water with the CO2 below 200 m depth, which should prevent short-term release.

This lower carbon path offers significant economic benefits through lower prices. At present, the average cost of diesel generation is about $0.26/kWh in Rwanda vs. the overall average cost of generation of $0.14/kWh (this is quoted in the World Bank Lake Kivu study), though other sources cite an average of $0.20/kWh or $0.23/kWh. The cost of generation from Lake Kivu IPP should be about $0.06-0.07/kWh (though other sources cite $0.09/kWh). This will lower the overall cost of power generation significantly, with some estimates of a reduction of 50%.

The low carbon projects (including hydro) also will provide greater energy security, reductions in air pollution, reduction in forests (and deforestation) for energy, reduction in energy imports (balance of payments) and offer potential for electricity exports (regional). There is also the benefit of potentially reducing the risk of a gas eruption (or even explosion) from the methane in the Lake.

There is also potential from micro-hydro, some of which may be connected to the grid, but some of which will be on micro-grids. Rwanda's topography means that network construction costs are high, reaching up to US$80,000 per km. Numerous rivers offer the potential for micro-hydro generation. The energy policy outlines 21 such projects, with a total capacity of approximately 13 MW by GoR, BTC, GTZ, bilateral donors and private investors. These are not captured in the numbers here (not least because they might be stand-alone systems) but would also offer many advantages, in terms of costs[3] and environment, by replacing potential stand alone diesel and in increasing access to electricity to remote areas..

Possible baseline and counter-factual scenarios

In looking at the potential for policy targets and carbon financing, it is necessary to consider the alternative scenario against which individual policies - or the entire sector - can be compared. This is an area that is difficult and has been a key issue in carbon financing.

In normal policy appraisal, the convention for the baseline is to look at the situation of what would have happened in the absence of a policy intervention. This normally includes an assessment of the effect of current and planned policies.

In CDM, the convention is to demonstrate additionality, defined as *additional to any that would occur in the absence of the certified project activity*, though this has been contentious. This works with a similar context, in terms of 'Business as Usual' (BaU), or, 'what would have happened in the absence of the CDM', though perhaps is interpreted in a stricter way in relation to laws and regulations, rather than also planned policy. There is also an investment analysis which acts as a precondition, and a barrier analysis.

[2] World Bank. Project Information Document (PID). Concept Stage. Report No.: AB2301
Martin Doevenspeck (2007). Lake Kivu's methane gas: natural risk, or source of energy and political security? Afrika Spectrum 42 (2007) 1: 91-106.

[3] Micro-hydro can deliver electricity for US¢10-20/kilo watt (s) per hour (kWh), less than one-quarter of the US¢40-60/kWh for comparably-sized gasoline and diesel engine generators.

Mueller 2009; Additionality in the Clean Development Mechanism[4] outlines that the methodology for establishing the baseline essentially involves putting up a list of scenarios – descriptions of projects that 'provide outputs or services with comparable quality, properties and application areas as the proposed CD project activity (including the project and all alternatives) − which are practically possible with respect to available technologies, potential barriers, and legal constraints,' and then designating the 'most economically or financially attractive alternative scenario' as 'baseline scenario'. In terms of credits, the approach usually uses historic data, so that the offsetting baseline for renewable projects feeding into that micro-regime, defined by the average emissions intensity of the grid over the past five years.

In ETS type arrangements, the convention is to relate to a validated recent base year, where emission data are available, to provide allowances.

At this stage we do not focus in on any one type of mechanism, so we have produced a number of alternative projections to the current 'planned policy estimate' outlined above. These include:

- Extension of the baseline mix, e.g. assuming a 2005/6/7/8 mix. Note that the grid intensity of the mix has changed rapidly over recent years – it was very low in 2005, then increased with rented diesel. Note that the base year chosen, or average of base years, will have a large effect on the future assumed emissions for the current planned policy (and additional schemes) and thus on potential carbon credits.

- Some type of alternative high fossil scenario. This is problematic for a number of reasons. First, the current policy and fuel mix only has a high proportion of fossil generation, so it is unrealistic to point to a higher mix of fossils. Second, fossil (diesel/HFO) has much higher price per unit of electricity than renewables and other alternatives. A high fossil mix can therefore not be considered a valid counter-factual or additionality baseline. This point is extremely important for a negotiating position, and in the allocation of any cap or target. Moreover in reality, a high fossil mix would be much more expensive, and higher prices would therefore reduce demand from the levels outlined above. A value has been derived assuming similar carbon intensity to the new HFO plants (~900 gCO_2/kWh, taking into account transmission losses), but without any reductions in demand despite the higher prices. We believe any high fossil scenario can only be considered illustrative.

- We have included a Kivu only mix, to highlight that this leads to higher emissions than the planned policy mix, and that if a later phase of Kivu (in excess of planned total of 200 MW) comes on stream, emissions will rise, and so will carbon intensity. However, there is the potential that later phases could be used for exports, and displace other power in the region, which would be beneficial if displacing coal in the region.

- It is also useful to look at what could be achieved in terms of a lower carbon path below the 'planned policy estimate'. The simplest scenario would be based on the further introduction of renewable energy, e.g. wind, hydro, to replace the existing diesel and HFO plants, rather than further extensions of Lake Kivu (see notes above about Kivu). At this stage we have not considered a scenario where renewables displace planned Kivu capacity. There are some clear risks with a strategy to remove these plants, due to reduced diversity of generation options increasing vulnerability to outages, fewer options for load balancing and increasing reliance on hydro generation. Clear benefits would be a reduction in fossil imports, and lower costs of generation. Careful consideration would need to be given to grid operability before removing this fossil generation; in addition, the HFO plant is new and therefore shutting this plant down early may not be economically viable.

- There is the issue of whether it is possible to include some type of intensity reduction. For the power sector, carbon per kWh of energy delivered is the most relevant metric (rather than carbon per joule, though they effectively the same). However, the problem is what baseline to track against. If compare to 2006/7/9, then the planned policy scenario is already delivering a reduction in carbon intensity that is greater than 10%. However, if earlier years are considered (2005 and before) the picture is not as clear. There is some potential for further reductions below the planned policy baseline, though these are quite low (see point above).

[4] http://www.oxfordenergy.org/pdfs/EV44.pdf

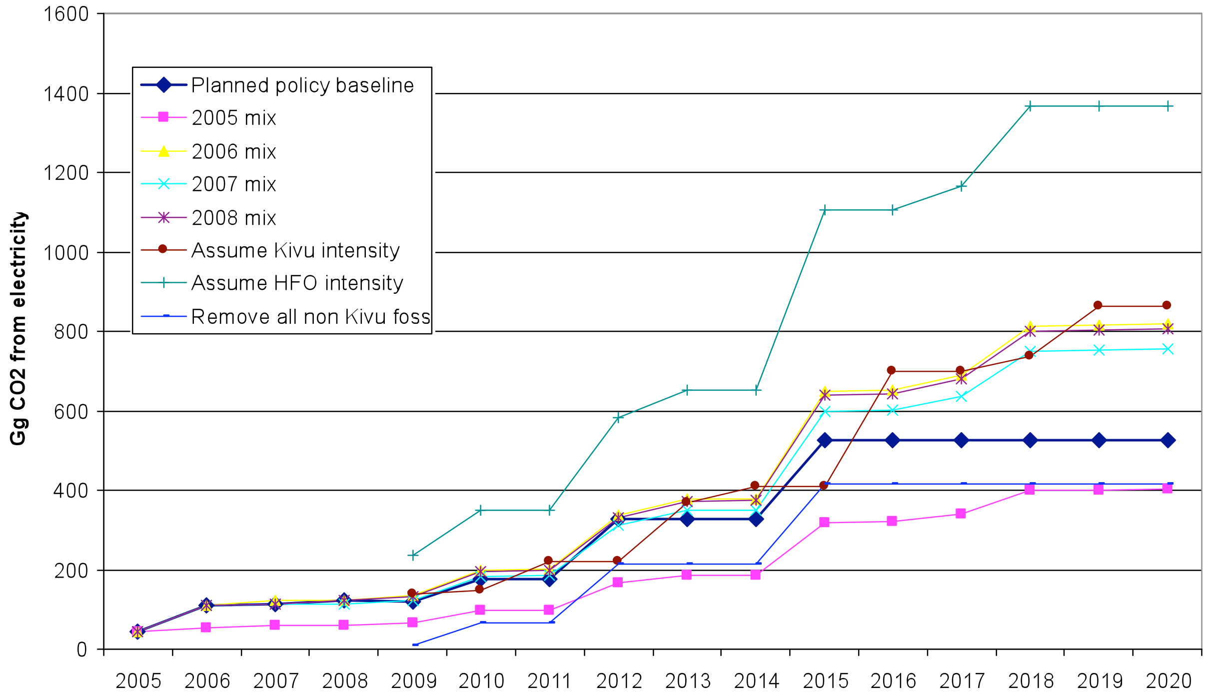


Figure 6. Projection of Total electricity emissions in Rwanda. Note projections are indicative only.

Gg CO_2	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Projected policy BAU	122	121	178	178	327	327	327	526	526	526	526	526	526
2005 mix constant	61	66	98	98	166	186	187	319	320	339	399	401	403
2006 mix constant	123	134	199	200	337	377	379	647	651	689	811	815	819
2007 mix constant	114	124	184	185	311	348	350	598	601	636	749	752	756
2008 mix constant	122	132	196	197	332	372	374	639	642	680	800	804	807
Assume Kivu intensity (for all generation)		138	149	220	220	368	411	411	698	698	736	863	863
Assume HFO intensity (for all generation)		235	348	348	584	651	651	1106	1106	1166	1367	1367	1367
Remove diesel + HFO from planned		9	66	66	215	215	215	414	414	414	414	414	414

Assumes renewables (e.g. hydro) replace diesel. Note if additional Lake Kivu displaces diesel, emissions will be higher.

- The baseline chosen/allowable will have a significant effect on the potential emissions benefits, and their potential for credits, though we note the issue of other additionality tests (finance as well).
- There is relatively little potential below the planned policy baseline, because there is a relatively small proportion of fossil power in the mix (excluding Lake Kivu). The total carbon flows from the whole electricity sector are also small, e.g. the entire energy system of Rwanda (500MW by 2020) is well below the size of one major power plant in a region such as China.
- Overall, Rwanda cannot aim for a zero carbon electricity sector. While it is on a low carbon path, future expansions of Lake Kivu resources would mean that future targets may not be achieved. A greener and lower carbon path would be to invest in hydropower and other low carbon options (wind).

It is highlighted the numbers above have been produced extremely quickly, and should therefore only be taken as indicative.

What are current / projected use / emissions in the transport sector?

Rwanda has an extremely small number of road transport vehicles, with only 75 000 registered total vehicles (vehicles recorded since 2001), of which over 30 000 are motorcycles. This is equivalent to around 8 vehicles per thousand people (note other sources have slightly different vehicle numbers).

In 2008, Rwanda imported 67.5 million litres of petrol, 99.2 million litres of diesel and 15.0 million litres of kerosene. Based on a 10% annual increase, this could grow to over 200 million litres of petrol, and over 300 million litres of diesel by 2020.

The actual coverage of the road network of Rwanda is dense and judged to be adequate, but only around one-fifth of the classified network (total classified network of 5300 km) is paved, and much less than this in the unclassified rural road network (total unclassified network of 8600 km). The improvement of the road network and transport costs and access is likely to be important for future planned improvements in the agricultural sector. There are no specific targets for transport access or costs within the Vision document.

Vision 2020 estimates that petroleum product consumption will increase by > 10% per annum. It will therefore be an increasing source of CO_2. These estimates have been used to project petroleum product emissions, shown below. The main driver for the growth is increased petrol and diesel.

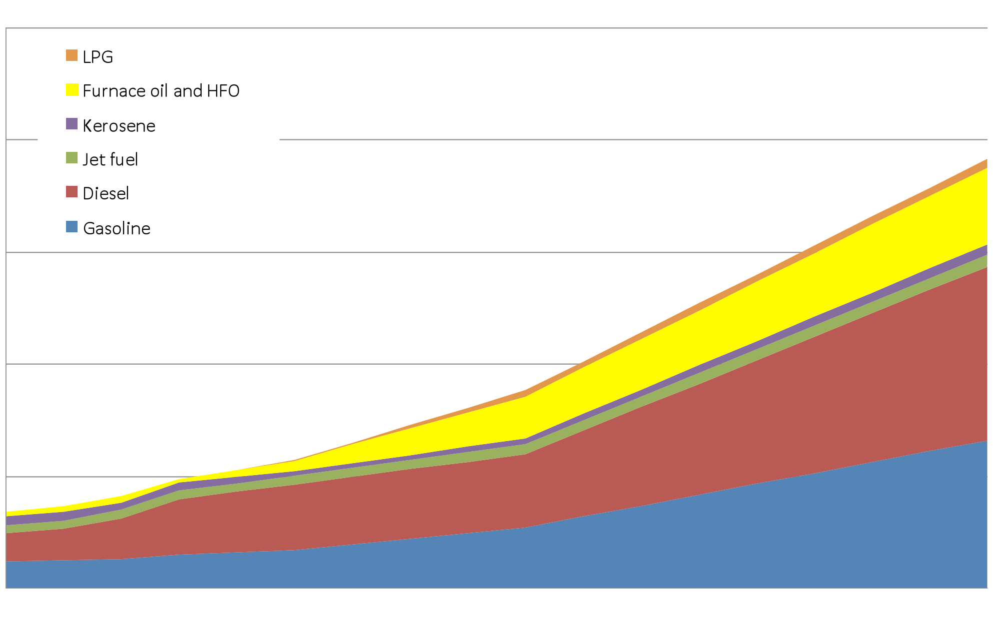


Figure 7. CO_2 from consumption petroleum products in Rwanda (Indicative only)

The increase in petroleum product and imports has implications due to the high import and transport price to Rwanda. Rwanda faces higher costs for this fuel than most other countries owing to its distance from a port and the delays of bringing the fuel across borders[5]. Low carbon options would therefore have economic benefits (lower costs and reduced payments of imports, potentially allowing scarce foreign exchange to be better spent on capital goods to enhance the growth potential). They would also have benefits in reducing the potential future problem of air quality (Kigali). There are also wider transport issues associated with strong increases in transport demand, notably urban congestion.

Note we have some price data for petrol and diesel imports, which we will work up to provide costs of imports for current and future.

To our knowledge, there is no low carbon plan for the transport sector currently for Rwanda. However, the recently published energy policy has objectives consistent with a lower carbon future, as set out in Box 1 below.

Orientation of energy policy in relation to the transport sector (GoR 2009)

- Promote energy conservation and efficiency through encouraging proper maintenance of vehicles and good driving practices. Programmes will be introduced to ensure proper maintenance of vehicles and fuel-efficient driving practices become the norm in Rwanda
- Encourage the development of affordable and well run mass transport systems so that the proliferation of individual goods and passenger vehicles is reduced.
- Reduce pollution by encouraging the use of environmentally friendly fossil fuels such as unleaded petrol and low sulphur diesel.
- Encourage research into alternative fuels for transport purposes, such as ethanol, methanol and biodiesel.

Transport represents the fastest growth source of emissions, and is a key issue because of growing urbanisation.

However, it is the hardest of all sectors to advance low carbon options and usually the least cost-effective (i.e. the highest marginal cost per tonne CO_2 abated).

Avoiding the future growth from this sector will be challenging. Policies to address transport also have high political barriers, because policies are often unpopular, and have strong distributional consequences (for the poor).

Options can be broadly categorised as follows:

- Vehicle efficiency improvement e.g. newer vehicles
- Advanced technologies
- Demand side measures e.g. behavioural change
- Fuel switching e.g. biofuels
- Modal shift e.g. private to public transport systems

More specific options are discussed below.

- Short-term technical solutions include the use of biofuels blended with conventional transport fuels and increased efficiency vehicles.

[5] Information on transport costs for CIF to Kigali indicates transport costs alone add 20% to 30% to the price of refined fuels, based on data for the first few months of 2009.

- Given the high import price of transport fuels in Rwanda, biofuels could be economically feasible, especially with potential carbon financing, but there are issues with large-scale production (limits beyond 5- 10% of biofuel added to conventional fuel; effects on air quality controls, competition for land resources, and pressures on natural resources). There could also be potential for regional imports of biofuels.

- Current Rwanda Government policy is to encourage careful research to be conducted into the potential of large-scale biofuel production in Rwanda taking into account not just the direct costs and benefits, but indirect opportunity costs - reductions in food crops and import substitution or export cash crops, the implications for use of water resources and the environment, net employment implications. It is also to support the development of small-scale biofuels projects which can supply biofuels appropriately and economically for particular applications e.g. remote rural grinding mills.

- However, Rwanda has very high population density, and there would be concerns that it could produce biofuel for the transport industry without compromising food production. It might be possible to encourage existing sugar factories to produce ethanol for transport sector, but this would not be a substantial amount, and chances of carbon finance benefits would be low (so far, no biofuel CDM project has been registered). Other alternatives might be introducing biodiesel feedstock for small scale farmers, or the use of biofuel is for stationary generators or households, which might attract funding through voluntary markets. There is some current work investigating the potential for biodiesel in Rwanda, and this will provide further information shortly on this potential option.

- One potential policy that is being considered is the use of the Lake Kivu gas resource for a 50 MW gas to liquid plant, producing diesel, jet fuel and kerosene, and that which might produce a maximum of 1000 barrels/day (possibly 158 ltr each). This would have the advantage of reducing imports, but would involve some increase in emissions from power for conversion process (though main emissions come from combustion, and these will not change whether the fuel is imported or not, unless lower prices allow for an increase in demand).

- Very new fuel efficient vehicles are now on international markets: these often have higher capital but lower operating costs, but this would be a barrier for the uptake in Rwanda. Another option might be to reduce the maximum age for 2nd hand cars to be imported. However, the efficiency across older (>10yrs) and more modern cars (e.g. 1 – 7 years) are not that different, as efficiency improvements were offset by the need to fit pollution abatement equipment[6], and this would have additional costs, though also additional benefits by reducing pollution.

- Newer technologies that are only just emerging in developed world markets and often cited as low emission include hybrid, plug-in hybrid and electric cars. Such technologies are currently extremely expensive as relatively new in the market. Based on known technology, average new vehicle efficiency could also be improved significantly through measures such as improved aerodynamics, weight reduction, low resistance tyres, regenerative braking, gear shift indicators etc.

- A more realistic and immediate potential might be through vehicle inspection and maintenance regimes (and roadworthiness), which can ensure vehicles are operating correctly and have wider benefits in terms of safety.

- There might also be potential for fuel switching to alternative fuels. Other cities have adopted CNG as an option, usually for the bus fleet though in some cases for all vehicles, and this could have some potential due to the Lake Kivu reserves (though with planned power expansions, and the introduction of gas to liquids and fertiliser applications, there may be little future capacity – there is also the potential costs to transport to the main transport demand centres such as Kigali).

[6] Emissions from the current European fleet ranges from 100 gCO_2/km to over 250 gCO_2/km, with an average of 160 gCO_2/km (2005) reduced from 185 gCO2/km in 1995, though part of this is due to a greater switch to diesel as a fuel. There was a voluntary target to achieve an average of 140 gCO_2/km on new cars by 2008 (though this was missed). There is legislation to achieve 130 gCO_2/km on new cars by 2012, falling to 120 gCO_2/km with biofuels and other measures (though vehicle technology have been calculated to be around Euro 1200 on average per vehicle).

- Longer-term technical solutions include alternative energy carriers (electric, methane, hydrogen), but these involve very high marginal costs. They would only be possible with large external demonstration (donor) funding.

- An equally significant issue for future transport arises from congestion. Other East African cities (Nairobi) are now extremely congested. Congestion significantly increases CO_2 emission, leads to significant air quality problems, and has a high economic cost (lost time). Technical solutions do not have the co-benefit of reducing congestion. A more sustainable transport policy, that included technical and non-technical solutions could reduce future congestion and give much greater overall benefits.

- Short-term non-technical solutions include greater public transport provision, stimulating behavioural policy through economic instruments on fuel, vehicles or infrastructure use (taxes and charges), etc. Long-term non-technical solutions include urban and spatial planning (to address urban sprawl with growing urbanisation). These offer large potential but involve co-ordinated and enforced land-use policy (e.g. compact cities for maximising public transport) – however, if not linked to measures to reduce private vehicles, then such plans can actually lead to higher congestion because of the concentration of activity.

- In the whole of East Africa, governments have invested little in public transport, and most public transport vehicles in cities are operated by private businesses leading to congestion and chaotic transport. This would be an area of potential focus.

- Behavioural measures are often the most cost-effective way of reducing fuel use, and reducing emissions – although often not easiest measure to introduce. Mckinsey (2009) suggest that improving traffic flow and driving behaviour (lower speeds, reduce acceleration / deceleration) could cost -$127/tCO2 i.e. negative costs due to the fuel savings. Improved driving behaviour can improve fuel efficiency by 17%. Another measure cited is reducing trip length and number through shift to other modes; Mckinsey (2009) again quote cost-effective values of $93/tCO2 although assumptions are not clear e.g. the opportunity cost of foregoing road travel.

- There is high uncertainty with any projections of future transport demand. The current projections assume linear extrapolation of current trends. However, private vehicle ownership is highly income dependent, and there are thresholds for car ownership (i.e. above certain per capita income, car ownership can rise exponentially). As an example, South Africa has 144 vehicles per thousand people (and 92 cars per thousand).

What are Emissions from Agriculture?

Agriculture contributes nearly 40% of GDP (2006) and employs almost 80% of the work force. It comprises traditional smallholder food crop (86% of agriculture) and livestock (6%) farming, fisheries (4%), forestry (1%) and export-orientated products (3%), principally tea ($32 m in 2006) and coffee ($54 m)[7]

Emissions from the agriculture sector have been made in the draft 2nd National Communication. These are of course subject to review, and are currently draft (GoR 2008). The provision estimates show emissions are almost 2.5 times higher than previously estimated for 2002, in the 1st National Communication. This is primarily driven by much higher estimates for the largest emitting sources – N2O from soil cultivation and CH4 from enteric fermentation. This is likely to be due to significant changes in emissions accounting methodologies under the Revised 1996 emission inventory reporting guidelines issued by the IPCC.

[7] Sources Of And Obstacles To Economic Growth In Rwanda: An Analytical Overview

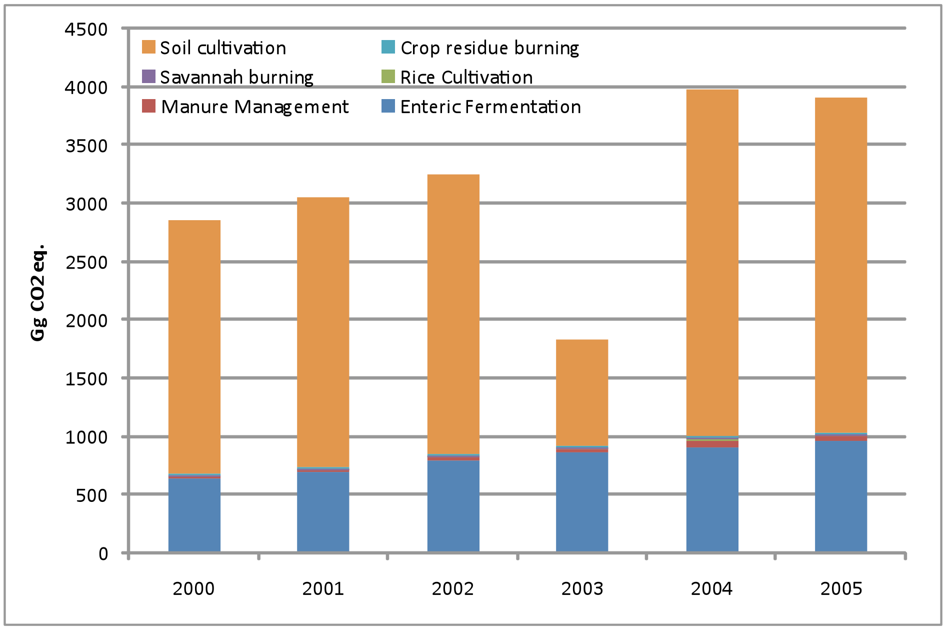


Figure 8. Rwandan GHG emissions 2001-2005 (2nd NC) by greenhouse gas for agriculture sector

The drop in N2O emissions in 2003 (shown in Figure 5) is explained by a significant reduction in crop production caused by late and heavy rains

Overall there has been an increase of 7.1% in the area cultivated from 1.51 million ha in 2000 to 1.62 million ha in 2005, and a 41% increase in yields. Livestock production has increased by 60% over five years from 2000 to 2005.

Projections in this sector are difficult. It is unclear what level of fertilisers will be used. Changes in livestock numbers, and therefore enteric emissions, are unknown. It could be assumed that these fall at the same rate as the agricultural population but again this will depend on whether there is a shift to intensification, and a shift in diet, market potential, etc. There are also complex interactions, i.e. with fertlizer use and soil erosion reduction, soils could store more carbon.

GHG emission estimates have been made out to 2020, based primarily on the growth drivers provided in the Vision 2020 document (GoR 2000), and starting from the 2005 Reference year in the draft 2nd National Communication (GoR 2008). However, we highlight that these are very approximate only. A key assumption in the projections is a 7% annual growth rate for GDP out to 2020. Vision 2020 outlines the transformation of agriculture into a productive, high value, market oriented sector, with forward linkages to other sectors. Agricultural policy orientation will have to be overhauled, promoting intensification so as to increase productivity and achieve growth rates of 4.5 % to 5% per year. These rates are reasonable: economy-wide Multi-market Modelling carried out by IFPRI for the World Bank[8] suggests that the agricultural sector could grow at an average annual rate of 6%, with yield and cropped area increases, with most growth from food staples, and just over a quarter from export crops. The shift can only happen through the production of high value crops and modern livestock management. The vision aims to replace subsistence farming by a fully monetized, commercial agricultural sector by 2020.

Emissions influenced by fertiliser use are disaggregated in the 2nd NC, and account for about 47% of total emissions from soil cultivation. We have then applied the growth rate in fertiliser application to this part of the emissions total; this seems like a fair approach given that this is how the IPCC Tier 1 methodology works, and is the Tier used by Rwanda in the current draft 2nd NC. In the EDPRS 2008-2012 (GoR 2007), the Vision 2020 target for agricultural households using fertilisers is targeted to rise from 16% in 2006/7 to 20% by 2010 and 50% by 2020. We have simply applied this type of growth rate to emissions from fertilisers. To project N2O, we have taken a very simplistic approach, assumed that all sources remain the same except for

[8] World Bank (2007) Promoting Pro-Poor Agricultural Growth in Rwanda: Challenges and Opportunities, paragraphs 186-88

the emissions relating to fertiliser use. We project neither ad increase nor decrease in emissions from these specific soil cultivation emission sources.

The issue of fertizer use is important, because these are highly energy intensity to produce. Fertiliser use in Rwanda is lower than in other countries in the region, while soil nutrient losses are among the highest. For Rwanda, they are also expensive to import. Imports have been growing steadily since 1995, at an increase of around 1000 t/year, and there were total imports of more than 14,000 t in 2008. Any forecasts of growing fertilizer use will have some negative effects in terms of rising costs of imports. However, there is no increase in domestic emissions associated with fertilizer production, as the carbon is embodied in the product. There is a proposal (concept phase) to use the Lake Kivu methane gas resource for fertilizer production (urea), with a preliminary feasibility study undertaken and a comprehensive market study to be conducted. The plans are for a facility which is large enough to produce exports as well as meet domestic consumption, and the level of potential export markets will determine the plant size. This would have advantages in terms of lowering costs of fertizer, reducing import payments and potentially allowing scarce foreign exchange to be better spent on capital goods to enhance growth potential, but it would increase the domestic emissions of carbon, because the energy used in production would be allocated to Rwanda. Based on the proposals (a 50 MW facility) and assuming combustion of methane, a very approximate estimate is an extra 100 Gg of CO_2 per year. Note that these emissions would be classified under the industry sector, rather than agriculture.

Livestock projections are the main driver for CH4 projections. In the absence of animal projections, we have assumed emissions increase at the rate of livestock production observed in the last 5 years continue out to 2020. This would seem a reasonable assumption, when we factor in population growth, the deficit in livestock supply versus demand and the increasing per capita demands as incomes increase.

<u>Additional information is needed to establish the method used to make estimates more robust, and develop better activity estimates for future years. I</u>

There are potential options for reducing emissions in the agricultural sector. There are a range of mitigation measures that could be considered to address these sources. Whilst measures on the whole are low or negative cost, the issues come with respect to implementation, particular across a sector that is often fragmented, with many smaller farms and small-holdings. This inevitably makes policy implementation more problematic (Mckinsey 2009b).

Key measures are summarised in the Box below, and primarily sourced from the IPCC 4th Assessment Report WG3 (Smith et al. 2007):

Mitigation measures in agriculture

<u>Cropland management</u>

- Nutrient management, particularly with respect to method and timing of fertiliser application, to improve N use efficiency
- Reducing or no tillage farming practices. Soil disturbance tends to stimulate soil carbon losses through enhanced decomposition and erosion; reduced tillage can avoid / reduce losses
- Water management. Increased or more effective irrigation can enhance carbon storage in soils through increased yields and residue returns [-ve: potential gains offset by energy for pumping, increased emissions from fertilisers]
- Rice management. Reduce CH_4 emissions through various practices including draining and using alternative rice varieties.
- Agro-forestry is the production of livestock or food crops on land that also grows trees for timber, firewood, or other tree products. [+ve: strong synergies forest protection, and adaptation; -ve: lower intensity of yields]
- Returning cropland to another land cover, increasing the carbon storage in soils / vegetation

<u>Grazing land management and pasture improvement</u>

- Grazing intensity (and timing) can influence the removal, growth, carbon allocation, and flora of grasslands, and therefore affecting level of carbon accrual in soils
- Increasing productivity e.g. fertilisers. Application can increase yields and carbon storage. However, it can also lead to N_2O emissions thereby offsetting some of the benefits.
- Nutrient management – as mentioned above for croplands
- Reducing biomass burning, as this can lead to CH_4 emissions from combustion, reduce the albedo of the land surface, plus contribute to climate change through different indirect ways.
- Species introduction: Introducing grass species with higher productivity, or carbon allocation to deeper roots, has been shown to increase soil carbon.

Livestock management

- Improved feeding practices, for example, feeding more concentrates, normally replacing forages. Although concentrates may increase daily methane emissions per animal, emissions per kg feed intake and per kg-product are almost invariably reduced.
- Specific agents and dietary additives. A wide range of specific agents, mostly aimed at suppressing methanogenesis, has been proposed as dietary additives to reduce CH4 emissions.
- Longer-term management changes and animal breeding. Increasing productivity through breeding and better management practices, such as a reduction in the number of replacement heifers, often reduces methane output per unit of animal product.

Other measures include:

- Management of organic/peaty soils. Due to the high storage of carbon in such soils, use of these soils for agriculture can lead to CO_2 / N_2O emissions in particular. This is because soils are drained, which aerates the soil, favouring decomposition. Emissions can be reduced by practices such as avoiding row crops and tubers, avoiding deep ploughing, and maintaining a shallower water table. The most important mitigation practice is avoiding the drainage of these soils in the first place or re-establishing a high water table
- Restoration of degraded lands, which may lead to enhanced carbon storage. Such measures have strong synergies with adaptation.
- Manure management. Animal manures can release significant amounts of N_2O and CH_4 during storage, but the magnitude of these emissions varies. Methane emissions from manure stored in lagoons or tanks can be reduced by cooling, use of solid covers, mechanically separating solids from slurry, or by capturing the CH4 emitted. The manures can also be digested anaerobically to maximize CH_4 retrieval as a renewable.

Based on the First National Communication (GoR 2005), a number of the above options are cited as possible actions; however, it is not clear from the document what is actually planned or being implemented. The Second National Communication (GoR 2008) is currently being drafted, and it is not clear yet what measures will be published.

There are some key issues in the agriculture sector in Rwanda in relation to GHGs:

- An ambition to intensify agricultural production could increase GHGs through more intensive use of the land for crops. This could be through increase use of nitrogen based fertilisers. Intensification needs to consider good nutrient management, low impact farming measures (reduced tillage), and ways of ensuring carbon storage in soils is maintained / enhanced. This of course has to be balanced against the critical issue of food security.

- There is already a deficit in livestock production supply relative to demand. Furthermore increasing population and growing income will lead to increasing demand. Careful management of an increasing livestock herd will be needed to minimise CH_4 emissions per unit of livestock production.

- Agriculture is an important sector to Rwanda, and will continue to remain so for the foreseeable future. Developing a mitigation strategy in tandem with adaptation strategy will be key to ensure Rwandan agriculture remain and moves further to being a lower GHG sector in the future whilst coping with climate impacts.

Implementation is the difficult issue with agricultural measures as opposed to cost. Mckinsey (2009b) analysis suggests that over 90% of abatement potential in 2030 could be achieved at a cost of less than $10 per tonne CO2 eq. (NB. Actual data in euros; assumed parity between currencies). Hence the policy mechanisms for delivering the potential savings are key, particularly as these will have to ensure any mitigation measures do not compromise Rwandan food security.

Forestry

In future years, waste emissions are considered to increase at the same rate as population, while emissions / sinks in LUCF are held at the same level. While there are likely to be some pressure on forestry resources due to population and economic growth, policy makers also realise the importance of this resource. According to the EPDRS (GoR 2007), forest cover targets in the Vision 2020 are 30%, up from the current level of 20% (in 2006/7). In addition, this report states objectives of the 2008-2012 strategy to increase the proportion of protected areas for biodiversity preservation from 8% to 10% in 2012. Forest and agro-forest coverage is scheduled to increase from 20% to 23% of total surface land area, and annual wood consumption is due to be reduced by 30% from the 2002 figure. Soil erosion and soil fertility decline will be reduced by 24% over the EDPRS period.

What are emissions from industry?

The current economy of Rwanda is dominated by agriculture and services – industry is a relatively small part. In the medium to long term, the service sector is the target for Rwanda's economy.

At present, manufacturing dominates industrial output. The share of mining and quarrying in GDP is low (though important for exports). The largest increase within industry has been in construction, which has grown from 36% to 46% of industrial output. This is partly government infrastructure expenditure, and partly a private sector boom in residential construction.

The energy used in industry is captured in the early energy emissions. Note that due to historic power outages, an estimated 75% of Rwandan firms have access to private generators. An average of 45% of these Rwandan firms' electricity comes from their generators.

Note that the fertiliser plant using Lake Kivu methane for urea production – discussed in agricultural sector – would also increase industrial emissions, as would the potential gas to liquid plant.

There are low carbon options for industry, mostly built around energy efficiency improvements. This is regional data, with studies in Kenya on energy improvements that could be possible. There is also the potential for fuel switching. If this is to electricity (renewable) this is beneficial. If it is to wood products, this depends on the source.

Domestic, commercial, service and public sectors

Biomass energy accounts for the vast majority of the population's domestic energy needs (94%), and energy in small-scale commercial and public sectors.

Biomass, primarily used in domestic, commercial and public sectors, is forecast to increase by 2.3% annually, the same rate as population growth. This increase in biomass use factors in population growth but not the increasing per capita energy needs that will occur through economic growth. These increasing needs are likely to be met by other fuels (such as LPG / kerosene, particularly for cooking – see petroleum product projections) and electricity.

There has been a government initiative to ensure improved fuel stoves are used in all households by 2012; currently, 50% of households have improved stoves (GoR 2009). It has been assumed that the resulting efficiency savings have been factored in the projections.

Other fuels that may well reduce future use of biomass include peat and biogas. The National Domestic Biogas Programme (NDBP) has an objective to install at least 15,000 biogas digesters in rural households owning 2 – 3 cows by the end of 2011. Biogas technology has also been successfully introduced in prisons; this is set to be expanded out to schools and hospitals (GoR 2009).

Peat may also play an increasing role with reserves estimated at 155 million tonnes. Peat can replace firewood for domestic cooking and heating if technical adaptations of the stoves for smoke evacuation are properly taken care of; further research is ongoing about how to use peat. Other uses are also being considered – a cement factory is expected to start the large scale use of peat for heating purposes by 2008/09. An energy company is also preparing a 10 MW peat generation project to produce electricity primarily for the cement factory, with any surplus to grid.

It is important to note, that while a potentially significant resource to meet some energy needs, the IPCC does not regard peat as carbon-free. In the latest guidelines, it states that although peat is not strictly speaking a fossil fuel, its greenhouse gas emission characteristics have been shown in life cycle studies to be comparable to that of fossil fuels. Therefore, the CO2 emissions from combustion of peat are included in the national emissions as for fossil fuels (IPCC 2006).

There are two main reasons for improving the efficiency of biomass use –

- Emissions of non-CO_2 GHGs, in particular methane (largest single source in 2002 inventory)
- Reducing pressure on the natural resources of Rwanda

Policy aims include promotion of more efficient stoves, more efficient charcoal production and promotion of alternative energy (biogas, LPG, kerosene) (GoR 2009). According to the projections, biomass use on a household basis is projected to fall slightly, although will go up in absolute terms due to population growth. There is significant potential for reducing consumption.

<u>Improved stoves.</u> This measure has already been widely implemented; more than 50% of households owned an improved stove in 2008; by the end of 2012, the aim is to have reached 100% coverage (GoR 2009). Better stoves are likely to be on the market; however, the efficiency differential compared to those being introduced is unclear.

<u>Biogas digesters.</u> The National Domestic Biogas Programme (NDBP, funded by the Dutch Government) implemented by MININFRA aims to install at least 15,000 biogas digesters in rural households owning 2 – 3 cows by the end of 2011 (GoR 2009). Biogas digesters, successfully implemented in prisons, are also to be used in other public sector institutions e.g. schools. Such institutions, often in urban areas, have limited access on biomass, and where they do, often place significant pressures on this resource.

What are current and projected use and emissions in the energy sector and the overall economy?

Total energy related GHG emissions are predicted to more than double over the next 10-12 years. This is primarily driven by the growth in road transport emissions, shown below.

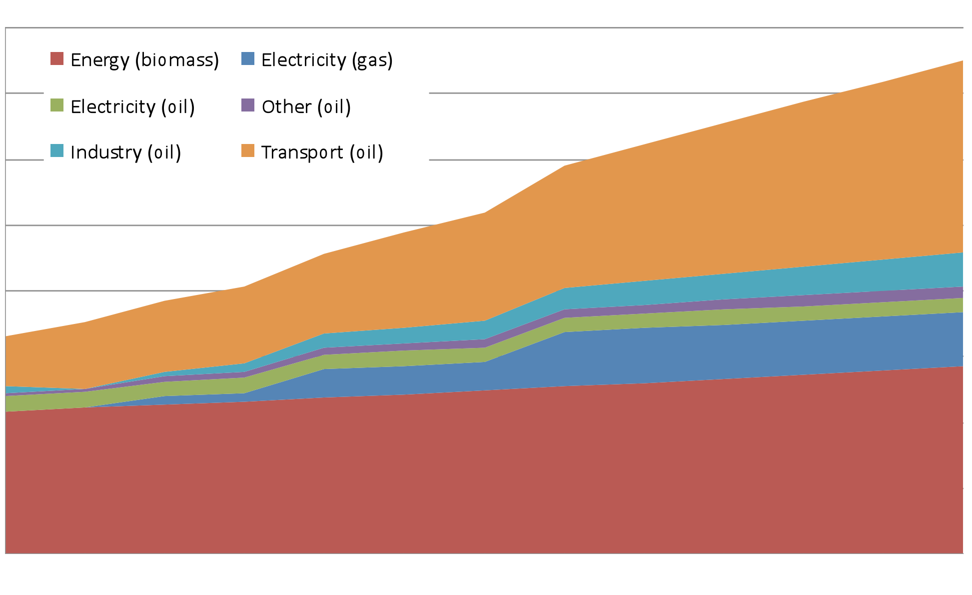


Figure 9. Projected CO2 (Gg CO2 eq.) from energy sector in Rwanda (note indicative only)

Note that additional energy sources from the potential use of Lake Kivu for fertilizer or gas to liquids would increase these totals, though it would probably be relatively modest (perhaps a 5% increase to total emissions). When agriculture and waste added, as below, the emissions rise significantly, shown below.

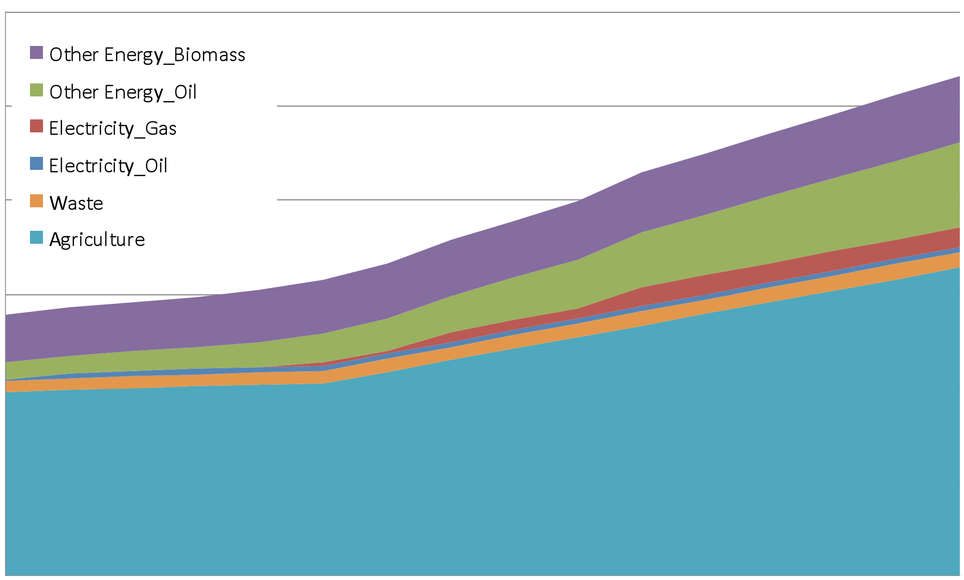


Figure 10. Projected GHG (Gg CO2 eq.) exc. land-use from overall country of Rwanda (note high uncertainties in projections, thus these should only be treated as indicative)

The total emissions increase slightly when land-use change is included, shown in the graph below.

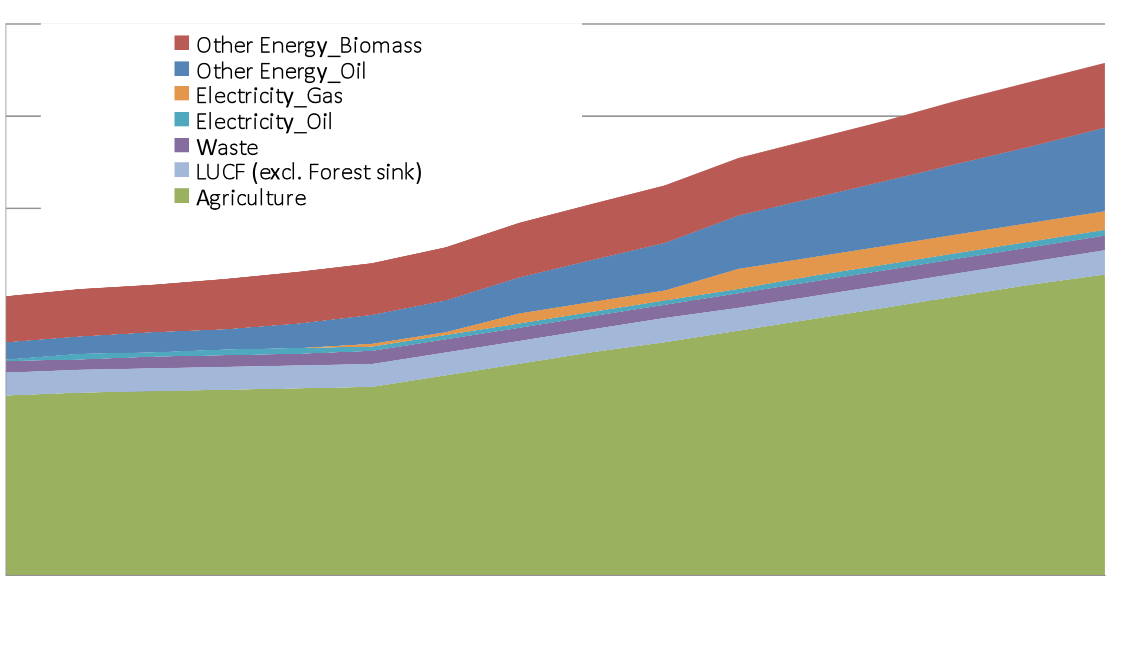


Figure 11. Projected GHG (Gg CO2 eq.) including land-use change from overall country of Rwanda (note high uncertainties in projections, thus these should only be treated as indicative)

Note that at present, Rwanda is a net sequester of emissions due to forestry sinks, which are estimated to absorb around 7500 Gg of CO_2 per year. These have also been factored into a projection set, assuming this remains constant over time. When this is added to emissions, the following net projection is shown, with Rwanda becoming a net emitter in 2012. Changes to afforestation or deforestation would affect the numbers below.

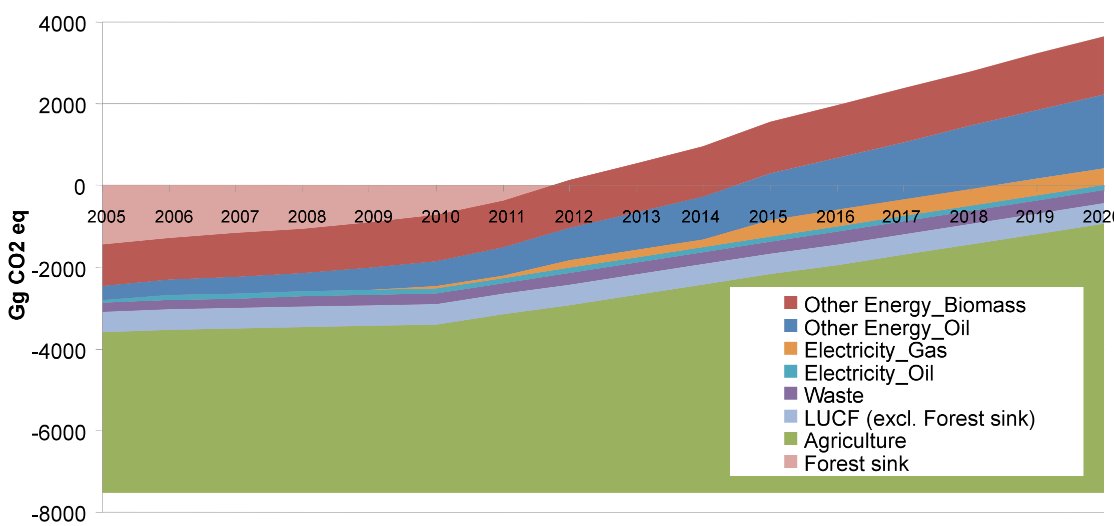


Figure 12. Projected GHG (Gg CO2 eq.) including land-use change and forest sinks from Rwanda (note high uncertainties in projections, thus these should only be treated as indicative)

Whilst we believe that the above projections provide a useful starting point for thinking through future projections and low carbon pathways, we also highlight a number of key uncertainties in the above projections:

- Some of the Vision 2020 targets which have been used in these projections do not look like they will be met; therefore, some of the growth forecasts might be deemed overly optimistic
- The agriculture projections have been estimated using a simplistic approach, and would benefit from much greater consideration. The forecasts here have high uncertainty.
- Electricity emissions could be considerably lower, if growth forecasts are too high, and Lake Kivu methane generation does not come online as expected.
- Transport emissions baselines and projections require further analytical work.

Low Carbon Opportunities

There is the potential to implement no regret (win-win) measures across many areas of economic activity in Rwanda, which are available at low cost now, and can improve economic efficiency, as well as delivering low carbon and development objectives. They also provide important co-benefits from reducing energy imports, enhancing energy security, improving air quality and health, reducing pressures on natural resources, and improving adaptation capability by exploiting synergies. There is also a large and untapped potential for low carbon - pro-poor economic growth projects, which can achieve poverty reduction and emission benefits through low carbon energy access programmes.

It is also important to adopt low carbon trajectories to ensure future growth avoids getting 'locked' in to high emission pathways, and to allow maximum potential for capturing financing opportunities now and in the future. In advancing all of these areas, there is an important role for domestic policy (taxation, regulatory, incentives etc) to encourage low carbon technology development, diffusion and deployment. This also includes the reform of fossil fuel subsidies and low electricity tariffs. Curbing deforestation is also part of this low carbon pathway, and is now the subject of potential new financing flows (reducing emissions from deforestation and forest degradation in developing countries (REDD)) and also provides protection of natural habitats and ecosystem services.

While there are suggestions on low carbon options across sectors, we also highlight the importance of domestic policy (taxation, regulatory, incentives etc) for encouraging low carbon technology development, diffusion and deployment. This also includes the reform of fossil fuel subsidies and low electricity tariffs.

Analysis of options for a lower carbon future

Options for low carbon growth in this study are not be considered only in term of GHG cost-effectiveness i.e. how much it costs to reduce a tonne of CO_2 eq. but rather take account of the wider interests in justifying investment above any other option e.g. economic growth and development, sustainability issues, energy security etc.

This means that while GHG cost-effectiveness remains a useful metric as a starting point for option appraisal, there are a wider range of factors to consider. Figure 1 below illustrates a framework for capturing some of the issues when considering options.

The first point to note is that a cost-effectiveness (C-E) metric on its own is not enough to indicate whether an option is attractive or not in mitigation terms i.e. for reducing GHG emissions. A number of other considerations need to be made.

- Economic rationality. For energy services, there may be an option that is much more cost-effective for reducing CO2 eq. emissions but delivers energy at a much higher cost. Therefore, for economic reasons, it may be very unattractive.
- Capital intensity. Many options may require high upfront capital investment. Such investment may be hard to come by, and therefore this issue needs to be considered.
- Fuel price sensitivity. C-E may be highly sensitive to changes in fuel prices, particularly where cost reduction is primarily based on fuel savings.

- Carbon intensity. Changing carbon intensity of electricity can drastically change the C-E of an option. For example, options that save electricity are likely to disbenefit from reducing carbon intensity in the generation sector.
- Local experience. Previous experience of option implementation and associated expertise can affect the C-E of an option, in terms of lowering costs and ensuring robust installation and maintenance which can affect emission reduction performance.

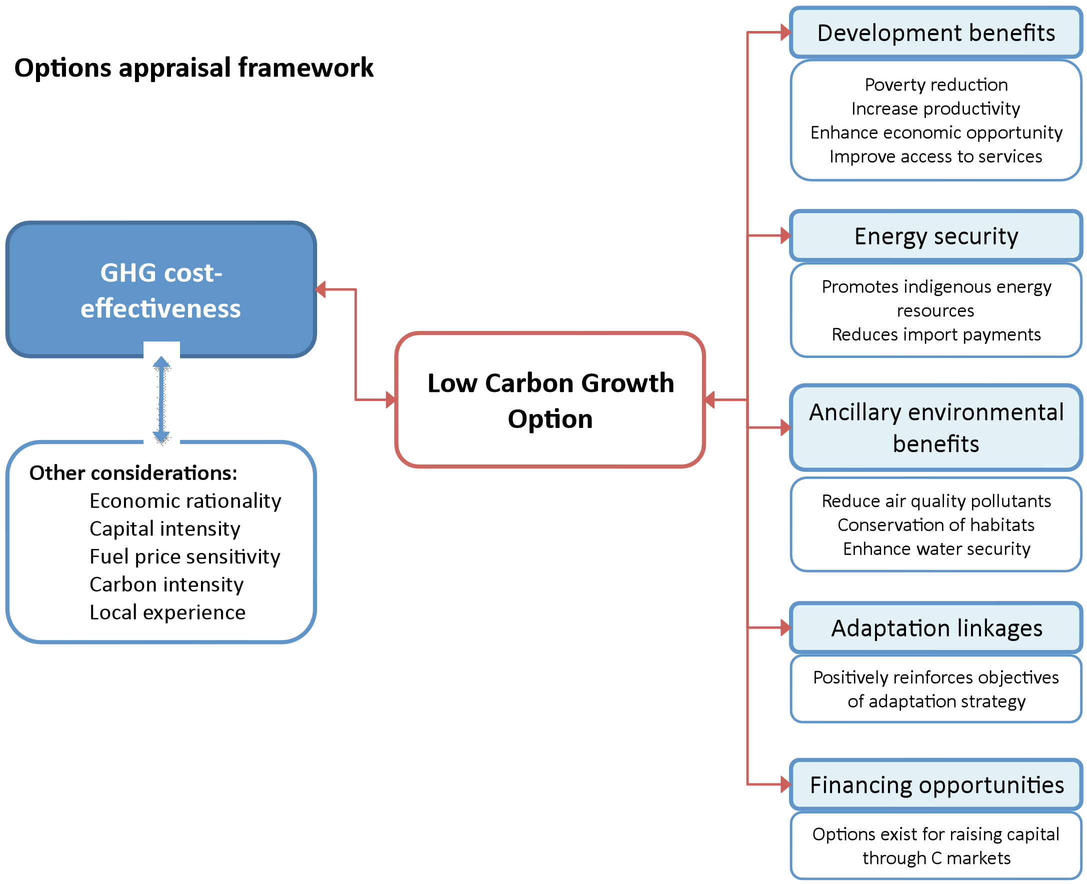


Figure 13 Options appraisal framework for low carbon growth options

In the context of very low overall and per capita emissions, East African countries should not justify take-up of a low carbon pathway on emission reduction alone; rather the focus should be on whether options further the objectives of other policy goals, as indicated in the Figure above. In particular, options should:

- Further the goals of development, including poverty alleviation and economic growth
- Promote greater energy security, particularly in reducing reliance on high price imports
- Enhance environmental sustainability
- Meet objectives of, or at least not conflict with, adaptation strategies
- Provide opportunities for investment through carbon financing

Assessment matrix of relevant options

Sector	Option	C-E?[1]	C-E level	Economic rationality	Capital intensity	Local knowledge	Development benefits	Environmental benefits	Energy security	Adaptation synergies	Other
Cent. Power[2]	Large Hydro	Yes	High	Strong	High	Strong	Increased supply Employment Social impact		High	Water storage Climate resilience of generation	
	Methane (Kivu) - CCGT	Yes	High	Strong	Medium	Limited	Increased supply Employment GHG emissions, albeit low		High	Less reliance on hydro	
Decent. Power	Micro Hydro										
Domestic / Commercial	Improved biomass stoves				Low	Strong	Lower fuel bills / time collecting fuel	Improved indoor air quality Reduced forestry resource use	Medium	Less pressure on forestry	
	Biogas digester	Yes		Strong	Medium	Strong	Lower fuel bills / time collecting fuel	Reduced forestry resource use Reduced CH4?	Medium		
Transport	Stock efficiency	Yes	High / Medium	Strong	High	-	Improved safety	Reduced pollution	Medium		High capital for consumer
	Biofuels	Unclear	-	Strong	Medium	Limited	Impacts on food security and other bioenergy Reduce transportation costs	Pressure on habitats Water needs	High		
	Driving behaviour	Yes	High	Strong	Low	-	Reduced transport costs Reduced pollution Improved safety	Reduced pollution	Medium		Difficult to implement

[1] Option reduces GHG emissions at negative or low costs relative to the alternative
[2] C-E assessment relative to diesel generation

Options in the NAPA

Possible projects to highlight with adaptation-mitigation linkages with:

1) **Priority option 4, Intensive agropastoral promotion:**
    a. Project 4.1 – Realization of three pilot farms in agrobioclimatic zones of East, South East and Central plateau.
    b. Aid to districts of vulnerable regions to prepare and implement measures of conservation and water storage.
    c. Realization of irrigation in gravitated parameters from water flows in vulnerable regions.
2) **Priority option 6, Development of energy alternative to firewood:**
    a. Preparation and implementation of national strategy for substitution of woody combustible to face climate change.

In relation to the second of these, there is Rwanda's National Biofuels Energy Strategy

Biomass comprises around 85% of Rwanda's primary energy, used mostly for charcoal in domestic cooking. The government's Biofuels Energy Strategy seeks to reduce the contribution of wood and charcoal to 60% of the national energy balance by 2020, with the remaining 40% derived from cleaner alternatives. Fuel substitution objectives aim to reach just over 20% of households in Kigali and 10% in other cities. Efforts towards conservation, introduction of improved cook stoves, sustainable woodlot management, and more efficient charcoal-making methods will reinforce these objectives (Biomass Energy Strategy (BEST), Rwanda, 2008).

Options in the 1st National Communication

This section outlines mitigation options suggested in Rwanda's FNC:

INDUSTRY SECTOR

Options to reduce greenhouse gas in the industry sector in Rwanda only concern carbon dioxide given off while producing cement, lime and tin.

Cement Production

In order to avoid production of CO2 related to industrial processes, we can choose artificial or natural binders without CaCO3 (slag, natural lime, truss, pouzzolanes, and volatile ashes).

In order to reduce the quantity and intensity of CO2 emissions from industrial processes of cement factory in Rwanda, it is recommended to CIMERWA to support programmes involved in the conservation of biodiversity, Nyungwe natural forest and in forestation programmes for Bugarama region in general.

Lime And Tin Industry

Reduction methods for CO2 emissions in the lime industry are the recuperation and storage of CO2, recycling, transformation by algae and tree plantations.

As for the lime industry, it would be necessary to sequestrate CO2 by Kabuye sugar works, ELECTROGAZ, construction and public works enterprises. Trees should also be planted near factories producing lime and use algae for small lime production units.

For the tin industry, appropriate industrial sites should be chosen and algae should be used to convert CO2 since the produced quantities are small.

Strategies to reduce greenhouse gases from industrial Processes

Strategies to reduce greenhouse gas in Rwanda are:

For the cement manufacture,

− Negotiate a protocol of understanding with CIMERWA so that the latter can voluntarily engage itself to reduce its emissions by 5 % between 2006-2008 and 8 % between 2010 and 2012;

− Partially replace the clinker with alternative binders free of $CaCO_3$ (slag and volatile ashes);

− Plant trees in the farmlands and support biodiversity and forests conservation.

For the lime industry,

− A protocol of understanding with the lime producers is necessary in a view to reduce emissions by 5 % / produced ton of lime during 5 years and support forestation programmes so as to increase carbon shafts.

For the tin industry,
− The strategy is similar to that of lime except that reduction of CO_2 emissions is by 5 % during 10 years.

Methods to be used to achieve the expected results are training, education, sensitisation, tax exemptions, low rate interest loans and other financial advantages.

AGRICULTURAL SECTOR

Measures To Reduce N2O Emissions

Options to reduce and management practices for reduction of N_2O in agricultural sector are:

Efficiency increase in the use of artificial fertilizers' nitrogen,

− Assess the fertilizer's contribution according to the plants' needs,

− Moderated manure spreading,

− Optimal synchronisation of spreading,

− Improvement of the soil aeration,

− Use of improved manure,

− Use of nitrification inhibitors.

Make sure that N is given off under N_2 form instead of N_2O by liming acid soils.

Measures To Reduce Ch4 Emissions

Intestinal fermentation,

Potential measures for reduction are:

− Reduction of the cattle herds according to respect of the carrying capacity per unit area of pasturelands;

− Productivity improvement;

− Improvement of food composition.

Management of manure,

Potential measures to be adopted for reduction of methane emissions from anaerobic fermentation in manure pits are the use of biogas digesters and reduction of fermentation materials.

Controlled burning of savannah and on- spot burning of farm residues,

Efforts to reduce emissions of GHG from controlled savannah burning and on -spot burning of farm residues will concern supervision, training and information of farmers as well as research – development on innovations for agriculture modernisation.

Strategies To Reduce GHG In Agriculture

Strategies and actions envisaged for reduction of GHG in agriculture are shown below:

Strategies Actions

-To extend the use of selected seeds and improved livestock breeds;

-To extend soil conservation techniques and use of farm manure;

-To sensitise the population in the use of micro-technologies to maximise profit from farm manure;

-To promote the use of farm inputs;

-To promote livestock stalling system.

LAND USE CHANGE AND FORESTRY SECTOR

Measures to reduce GHG can be classified into different categories if we consider the technical framework of conservation and management of forestry ecosystems, agro-ecosystems; others are related to institutional and sector policies; and finally to legislation in force.

Technical Options

The proposed technical and technological options for maintenance and increase of the existing forest cover are conservation of natural forests, rehabilitation of degraded forests and promotion of new tree plantations together with extension of agro forestry and use of alternative sources of energy.

Preservation Of National Forests

- Promotion of eco-tourism;
- Habitat and specie protection;
- Restoration of degraded areas;
- Research and monitoring;
- To involve the local communities

Preservation And Protection Of Relictual, Gallery Forests And Forestation

Rehabilitate and ensure protection according to the biodiversity that some sites have.

Agroforestry

Extension of agro-forestry trees which contribute in GHG reduction by permanent sequestration of an important proportion of CO_2.

Management Of Forest Energy Consumption

Pressure reduction on forestations and therefore on GHG sink sequestration will be done through utilisation of sustainable sources of energy. However, this requires a technological level from the users that can allow the use of other materials, production of accessible construction materials in local products that do not demand source of fuel wood (ex: adobe bricks, blocs), use improved cooking stoves and biogas digesters.

POLICY OPTIONS

Regional Development

In the framework of regional development general policy, a rational land use and proper wetlands management are necessary if we consider their role in hydrological regulation.

National Water Policy

A policy aiming at saving and management of water will have an impact on erosion's effects following rational rainwater management, maintenance of vegetation cover in all seasons notably through irrigation and increased plant and animal productions.

National Forestry Policy

The national forestry policy aims to preserve enough forest areas for protection of biological diversity, conservation of fragile ecosystems and maintenance of functions that forests and trees fulfil in the environment especially in water catchments areas.

Modernalisation Of Agriculture And Animal Husbandry

The agricultural policy targets promoting animal husbandry through stalling for up to approximately 500,000 heads and animal productivity. It also intends to increase carbon sequestration on farmlands through better management of residues and rehabilitation of degraded hillside soils.

3) Potential Targets and Baseline Values

In looking at the level of ambition, it is important to consider different ways of expressing low carbon pathways and ambitions. This is important, because the targets have different strengths and weaknesses, and different risks specifically for Rwanda.

Developed Annex I countries typically have commitments to absolute % reductions, relative to a base year, and this is usually the way they express forward targets or ambition levels[9]. However, this national level reduction approach is not appropriate for Rwanda. Instead, three alternatives are considered.

- National Caps
- Per capita targets
- Intensity targets

These have relevance in relation to any political announcement. However the primary aim of any target for Rwanda would be to maximise the potential for carbon credits as part of current, planned or future mechanisms, and they are therefore be considered in light of this.

Per Capita targets and Baseline Values for Rwanda

Some commentators are advancing the concept of per capita emissions, as an international benchmark. Global stabilisation of GHG gas concentrations at 'safe' levels implies that all countries may be required to reduce emissions to around 2 to 3 tonne CO_2e by 2050 (stabilisation at 450ppm to 550 ppm respectively by 2050, though even the lower level would still carry a very high level of risk).

Many developing country per capita emissions (including from land use) already exceed this value 2 to 3 tonne per capita target, and all developed countries exceed it considerably.

Rwanda has extremely low per capita emissions. When energy emissions only are included, these are amongst the lowest in the world. However, with agriculture, using the new reporting guidelines, these become much more significant.

The per capita emissions for Rwanda will increase over time, shown below for energy alone, and energy plus agriculture. By 2020, based on the projections above, it will reach 0.27 tonnes per CO_2 per person by 2020 for 'energy' only emission and 0.87 tonnes per CO_2 per person by 2020 for energy and agriculture and waste (new reporting guidelines). This assumes population growth in line with vision, with 13 million population by 2030[10].

The values are shown below for energy related emissions only, and for all emissions and land-use change (but excluding forestry sinks). The relative contribution by sector is also shown.

[9] As an example, the UK had a 12.5% GHG Kyoto reduction target relative to 1990; it is now bound by European targets (20% reduction overall for Europe) by 2020. It has also set national legally binding budgets for 5 year periods to 2022, and has a long-term binding target to achieve an 80% GHG reduction by 2050. However, the 2020 targets involve cost increases, with a marginal cost of £26/tCO2 for traded and £70/tCO2 for non-traded sectors) and the 2080 targets are estimated to cost between 1-2% of GDP in 2050. Norway has set an ambition to be carbon neutral by 2050, which means that all remaining emissions will be set off against emissions in other countries. However, this involves purchases carbon offsets from the market.

[10] The Rwandan population is expected to double to around 16 million by 2020, unless family planning improves, in which case the population is projected to reach 13 million.

Figure 14. Per Capita Emissions, Energy only and total emissions including land-use. (note high uncertainties in projections, thus these should only be treated as indicative)

Figure 15. Contribution to per Capita emissions by sector
(note high uncertainties in projections, thus these should only be treated as indicative)

Rwanda therefore has some potential to increase per capita emissions and still remain significantly below other Annex and non Annex I countries, and below a 2 tonne per capita global average. Note that based on a population of 9 million people in Rwanda currently, a 2 tonne per capita level would equate to 18 million tonnes of carbon – compared to the current emissions for Rwanda of 1.6 million tonnes (energy only) and 6 million tonnes (energy, waste and agriculture). Lower future per capita levels would also maximise future opportunities in a fully global trading market.

The table below shows per capita emissions for a number of countries, assuming different categories of emission sources. There is a big difference for developing countries whether values are expressed as CO_2 only or CO_2eq that is with all GHG – this makes less difference for major energy economies. Similarly there is a big difference on whether land-use is included for developing countries, though it makes little difference to major energy emitters.

Selected Per Capita Emissions Estimates, year 2000

Country/sector	WRI version 6.0 **CO2** excluding land-use change **Year 2000**	WRI version 6.0 **GHG** excluding land-use change **Year 2000**	WRI version 6.0 **GHG** and **land-use** change **year 2000**
Rwanda (WRI estimate)	0.1*	0.7**	1.6*
UK	9.0	10.8	10.8
USA	20.4	24.3	22.8
China	2.6	3.8	3.8
South Africa	6.9	8.7	8.8
Kenya	0.3	1.5	1.9
Europe	8.4	10.6	10.6
Sub-Saharan Africa	0.7	2.4	4.5
OECD	11.4	13.9	13.7
LDC	0.2	1.6	3.9
World	3.0	5.5	6.7

World Resources Institute, Climate Analysis Indicators Tool (CAIT) version 6.0. Data for 2005. Available at http://cait.wri.org. For CO2 only CO2 emissions per capita represents the mass of carbon dioxide (CO2) emitted per person for a country or region. CO2 emissions data used here represent the mass of CO2, a potent greenhouse gas, produced during the combustion of solid, liquid, and gaseous fuels, as well as from the manufacture of cement and gas flaring. Data are given in metric tons. CO2 emission values do not include emissions from land use change or emissions from bunker fuels used in international transportation.

* Based on 0.6 Mt CO2 and population of 9.2 million. ** Based on 5.5 Mt for all GHG and 12.9 Mt (year 2000) including GHG and land use change. This gives 0.7 per capita for all GHG and 1.6 per capita with land use also included.

However, some care must be taken in using these assumptions. First, we believe it is very unlikely for a negotiation process to allocate emissions on a per capita basis, as outlined in the next section. Second, some caution is needed in case countries assume that current low per capita levels remove the need for adopting a low carbon path now. This would be problematic, as it would cause problems for a country in the longer term, because of the lock-in to a high carbon pathway.

Intensity targets and Baseline Values for Rwanda

Another option, most advanced in the discussion of the major transition economies, are intensity targets. These asses the ratio of greenhouse gas emissions (GHGs) to economic output expressed in gross domestic product (GDP). Theoretically a GHG intensity target can lead to a net reduction in emissions, but only if it is sufficiently stringent. More usually, they allow net increase in emissions.

Rwanda's carbon intensity, based on the energy emissions alone, is 478 tCO_2/ Total $MillionGDP (2008) or if just non-agricultural GDP is used then 857 tCO_2/Non-agricultural $MillionGDP. However, when other sectors including agriculture and land-use change (but excluding forestry sinks) are added, the numbers increase very dramatically, to an estimated 1864 tCO_2/ Total $MillionGDP (2008). Note there is high uncertainty in these numbers.

Assuming the growth rates in the Vision document (around 7% a year), it is possible to look at the future intensity. Carbon intensity in the total energy sector remains broadly similar. When total emissions and land-use change (excluding sinks) are included, then carbon intensity of including energy and agriculture potentially declines through to 2020 but there is very high uncertainty with these predictions. The values are shown below.

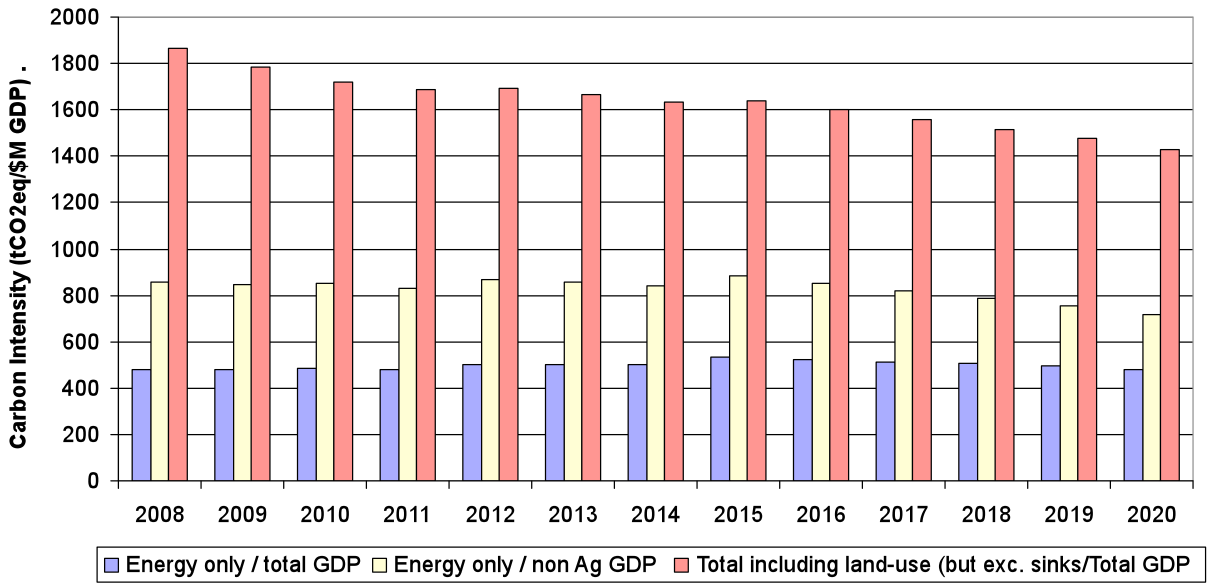


Figure 16. Projected Carbon intensity for Rwanda – energy only (divided by total GDP and non-agricultural GDP) and all emissions including land use (but excluding sinks).
(note high uncertainties in projections, thus these should only be treated as indicative)

Note values are not PPP adjusted.

Figure 17. Contribution to Carbon intensity by sector – all GHG including land use (but excluding sinks).
(note high uncertainties in projections, thus these should only be treated as indicative)

The values can be compared with other countries – noting that it is difficult to make exact comparisons because of emission reporting values. Again there is high variation according to whether CO_2 only, all GHG and whether land-use changes are included.

Selected Carbon intensity, Tons CO2 Eq./Mill. $Intl, year 2000

Country/sector	WRI estimate of carbon intensity CO2 and land use change only (2000)	WRI estimate of carbon intensity **all GHG** and land use (2000)
Rwanda (WRI estimate)	1,533.1*	2,471.5*
UK	316.5	377.8
USA	487.4	585.2
China	973.9	1,413.2
South Africa	927.0	1,172.7
Kenya	536.1	1,504.6
Europe	434.3	547.8
Sub-Saharan Africa	1,810.3	2866
OECD	409.0	500.9
LDC	2814.4	4,467.9
World	666.2	868.8

World Resources Institute, 2004 data. Climate Analysis Indicators Tool (CAIT) version 6.0. Data for 2005.

* based on 5.5 Mt for all GHG and 12.9 Mt including all GHG and land use in 2000 and $Intl 2000 $7,128 Million (though note this does not give the exact values cited in the model) Values for year 2000 seems to be broadly in line with values in this report, which have a value for GHG of 5.5. to 5.9 Gg.

The severity of an intensity targets depends on the future economic path, and whether this follows a shift away from energy intensive industries. The decoupling of emissions from economic output in OECD countries has been due to such shifts (though this has largely transferred greater intensity to the new manufacturing base such as China). The potential for a carbon intensity target will thus depend on the future economic structure in Rwanda: a move to a service based economy would provide much greater opportunity for intensity targets that go beyond maintaining current levels. The major aspiration of Vision 2020 is to transform Rwanda's economy into a middle income country (per capita income of about 900 USD per year, from 290 USD today), this will require an annual growth rate of at least 7%.

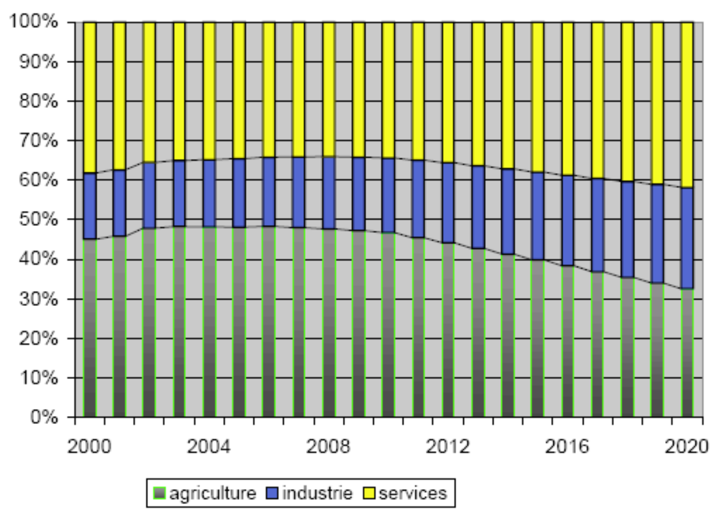


Figure 18. Sectoral contribution to GDP %

Republic of Rwanda (2000) Rwanda Vision 2020. Ministry of Finance and Economic Planning, Kigali.

Rwanda does not have a large industrial base, so intensity targets are less relevant than for countries such s as China. The economy is dominated by agriculture and services, and this is predicted to continue (though with the balance changing between the two). At present, Rwanda has extremely high carbon intensity at the economy wide level due to the agricultural emissions (total emissions/GDP). At the overall economy level, intensity should decrease due to improvements in agriculture, but these are highly uncertain. An intensity based target is therefore very risky, as well as not being very relevant.

The Chinese proposal to reduce emissions with 10% CO_2/joule and 20% joule/GDP measure are not very relevant for Rwanda, because the energy sector is a small proportion of total emissions. Moreover, the electricity generation sector is already on a low carbon planned policy path, and there is less potential to address transport emissions. We therefore do not believe it is appropriate to follow the Chinese model. These reasons (low carbon electricity planned policy, other energy emissions being dominated by transport) also negate any policy to adopt intensity targets for the energy sector alone.

National Caps

It is possible to set a national cap, setting a limit on future national emissions. One way to do this would be to set a reduction target (%) from a future business as usual. There has been discussion on the potential for a different type of cap, which takes into account future emissions growth, not dissimilar to the arrangements for some countries under the burden sharing agreements, e.g. within Europe, some Member States were allocated emissions growth above 1990 levels, to reflect the fact they were at lower level of economic development. There has also been discussion of the potential opportunities of Annex I countries and trading, and possibly similar mechanisms[11] and also the potential to recognise emission avoidance credits, i.e. that would be obtained relative to a business as usual.

The future emissions projections in this report are summarised below. This reflects a planned policy baseline, rather than any sort of counterfactual business as usual. It can be seen that emissions are planned to rise very significantly, almost doubling over the period.

Figure 17. Total projected GHG emissions excluding land-use change and forest sinks (note high uncertainties in projections, thus these should only be treated as indicative)

[11] This is the type of approach that is used in Annex I trading, with for example the European Trading Scheme, which covers over 11,000 installations. Within the current scheme, national governments are required to publish a National Allocation Plan (NAP), setting out the allocations for individual installations. This determines the overall level of 'cap' with the trading scheme. Companies are given allowances which represent their target (cap) for a compliance period. At the end of the period they must surrender sufficient allowances against their total emissions during the period. If their emissions are below their cap then they have allowances to sell, otherwise, they must purchase allowances from companies which have exceeded their emissions reductions targets. Allowances of CO2 traded on the market are known as EUAs (EU Allowances). The supply of allowances is fixed at the sum of the emission caps specified in the National Allocation Plans of each of the participating countries. The demand for allowances reflects current and anticipated levels of generation from fossil fuels sources, across the EU. The price of carbon allowances is therefore the same for all participants in the scheme.

Figure 18. Total projected GHG emissions with land-use change but excluding forest sinks (note high uncertainties in projections, thus these should only be treated as indicative)

While it could be possible to assess the potential reductions from a business as usual case (e.g. a national level reduction) the lack of information means that a detailed assessment of a realistic baseline and potential reductions cannot be made at present. This cautions against any discussion of national level baselines or national caps or reductions.

Moreover, the most difficult issue with any nationally based target, which has increased emissions built in, is how to set the counter-factual to compare against (i.e. how can one prove what would have happened in the absence of the low carbon policy, especially because emissions are strongly linked to growth projections, thus there might need to be continual adjustments).

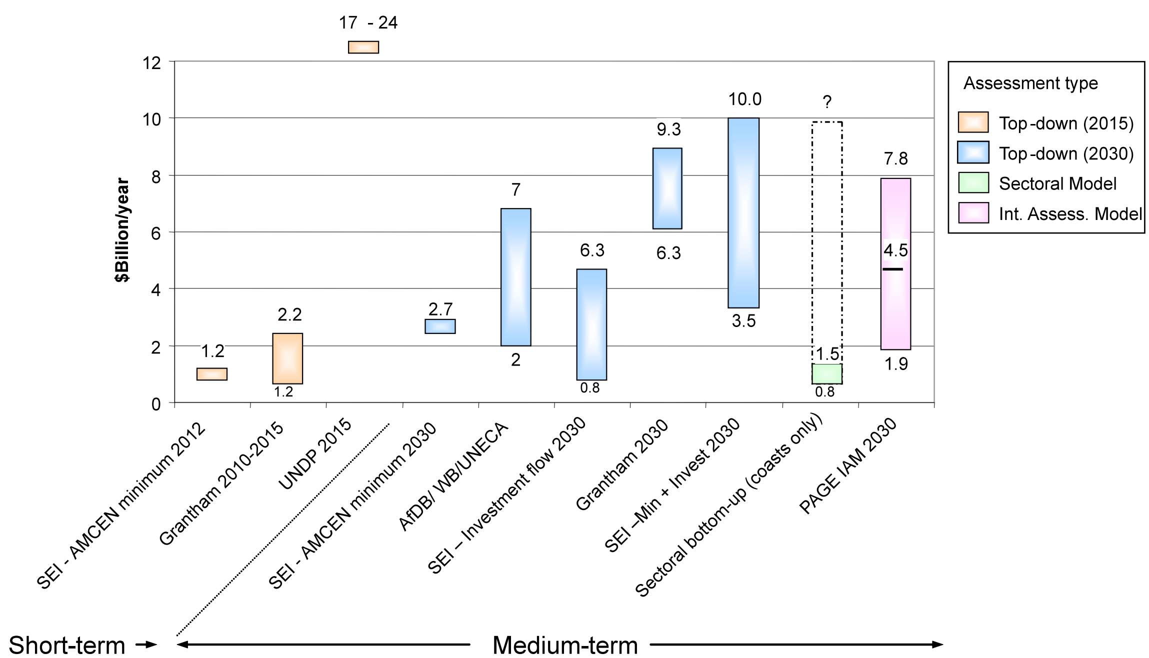
4) Impacts and Adaptation of Climate Change in Rwanda

As well as the potential for low carbon finance, it is important to consider other possible transfer mechanisms, particularly the planned Adaptation Fund.

The DFID study has been involved in a briefing note on the economics of climate change as part of the inputs to the Kigali meeting. This is available as a separate document. Note that climate change will have impacts across all the sectors considered in the previous sections, though these have not been taken into account in the projections (of activity or emissions). This is potentially important in many sectors, including water availability for hydro, potential for the agricultural sector, etc.

The note provides estimates of the economic costs of climate change in Africa, highlighting that economic models indicate these could be equivalent to 1.5 to 3% by 2030, and possibly more in countries that rely heavily on natural resources. Note a value of 1.5 to 3% equivalent GDP loss for Rwanda in 2020 (based on Vision GDP forecast) would equate to a cost of $115 to 230 million/year.

It also provides estimates of the potential adaptation needs for Africa, shown below, estimates of the short-term adaptation financing needs for Africa are typically in the range of $1 – 2 billion per year by the year 2012 - 2015. Estimates of the medium-term needs (2030) are typically in the range $2 - 10 billion per year by 2030.



Reported estimates of the costs of adaptation to climate change

There is therefore a potentially large source of adaptation finance for Africa. Entitlement to substantial funds (e.g. through the Adaptation Fund) must be assured, but effective mechanisms and institutions for access and effective use must be developed.

Using a similar approach to the AMCEN paper (see above), we have estimated the short-term potential adaptation funds needed for Rwanda.

Immediate adaptation priority funding needs for Rwanda, based on AMCEN approach

	Up to 2012	2012-2030
Assessing vulnerability	2 million US$/year	4 million US$/year
Building capacity	4 million US$/year	5.7 million US$/year adjusted to changes in aggregate level
Piloting adaptation	Using the project number identified in NAPA as a proxy indicator of project number: 3.5 million US$/ year	
Operational adaptation	Minimum 2 and approaching 10 million US$/ year by 2012	Minimum 10 and approaching 40 million US$/year by 2030
Total	11.5 million US$/year, rising to 21.5 million by 2012	Minimum:19.7 million US$/year Maximum: 49.7 million US$/year

To these need to be added the potential for making investment climate resilient. A range of estimates is provided, based on scaling the total adaptation costs (SEI) of Africa of US $0.9-6.3 billion per year. These should be added to the short-term priority needs above.

Adaptation funding needs for climate resilience for Rwanda, based on SEI investment flow approach

Scaling from total annual cost of climate-proofing investment associated with core financial inflows (minimum US$ ***946 million*** in total for Africa) (Details of measurement is exhibited in the table below)	On the basis of		
	Population	GDP	Land area
Rwanda	9.50 million US$/year	4.40 million US$/year	0.95 million US$/year
Scaling from total annual cost of climate-proofing investment associated with core financial inflows (maximum US$ ***6357 million*** in total for Africa) (Details of measurement is presented in the table below)	On the basis of		
	Population	GDP	Land area
Rwanda	63.86 million US$/year	29.54 million US$/year	6.38 million US$/year

This indicates potentially high adaptation needs, i.e. potential tens of millions per year, and a plausible upper estimate of $100 million per year by 2030. At this stage, it is unclear whether it is possible for such large funds (at a global level) to be obtained.

There is a large need for adaptation finance for Africa and Rwanda, and entitlement to substantial funds through the Adaptation Fund must be assured. This will be helped through a common negotiating position. However, accessing any funds will require the development of effective mechanisms and institutions within Rwanda. There is a need to consider the linkages between adaptation and low carbon pathways, and exploit the opportunities that arise from considering them together.

5) Negotiating Positions and Access to Carbon Finance

Current position of the negotiation

Daniel Bodansky, Visiting Fellow, Smith School of Enterprise and Environment

International Climate Negotiations

Background

The current Copenhagen negotiating process is currently proceeding along two tracks, one under the UN Framework Convention on Climate Change (UNFCCC) and the other under the Kyoto Protocol (KP):

The UNFCCC process was initiated in 2007 by the Bali Action Plan, which established an Ad Hoc Working Group on Long-Term Cooperative Action under the Convention (AWG-LCA), with the goal of reach[ing] an agreed outcome at COP-15 in Copenhagen. The Bali Action Plan process includes four pillars addressing mitigation, adaptation, financing and technology.

The KP process is considering new emission targets for Annex I (developed country) parties for the period after 2012, when the Protocol's first commitment period ends, and is being conducted in the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP).

At the last session of the AWG-LCA, the chairperson put forward a focus document that surveys the major issues and proposals. At the next session, he will submit a negotiating text, which will provide a starting point for the negotiations leading to Copenhagen in December. As inputs, a number of countries have put forward proposals for a Copenhagen outcome, including proposals for a long-term goal; developed country emission targets; nationally appropriate mitigation actions (NAMAs) by developing countries; financial commitments and mechanisms; mechanisms for technology development, diffusion and transfer; and adaptation actions and funding.

Given the continuing split in the negotiations between developed and developing countries, proposals likely to gain support among developed countries would prove controversial among developing countries, and vice versa. The African Group has already developed a detailed negotiating position, which proposes stringent emissions targets for developed countries, together with NAMAs for developing countries.

Legal form

Parties continue to disagree about whether there should be a single outcome in Copenhagen encompassing both the UNFCCC and KP tracks, or two outcomes, one under the UNFCCC and the other under the KP:

In general, developing countries have pushed for two outcomes: a new set of legally-binding emission targets for developed countries under the Kyoto Protocol, and a separate decision under the UNFCCC focusing primarily on (1) adaptation, and (2) financial and technological support for developing country NAMAs.

A number of developed countries, in contrast, have proposed a single Copenhagen outcome addressing commitments and actions by both developed and developing countries, which could incorporate by reference aspects of the Kyoto Protocol.

Although a new set of commitments by Annex I parties under the KP track would require a Protocol amendment, the Bali Action Plan leaves open the legal form of an outcome under the Convention. Options include (a) an amendment to the Convention; (b) a new legal agreement (either replacing or complementing the Kyoto Protocol); or (c) a COP decision. Several large developing countries have argued that the Bali Action Plan does not contemplate the adoption of an amendment or new protocol, and that the AWG-LCA outcome in Copenhagen should be a COP decision. This position apparently is motivated by a desire to avoid the adoption in Copenhagen of new commitments for developing countries. A number of developed countries, including the United States, have proposed the adoption of a new agreement, which could establish new commitments for developing countries.

Developed country commitments

Both developed and developing countries generally agree that the Copenhagen outcome should include new emission targets for developed countries. These could be adopted through a new agreement under the Convention or through an amendment to the Kyoto Protocol.

Thus far, developed countries have not, in general, indicated the level of ambition of a new round of targets. Nor is it clear whether the new set of targets would operate in the same top-down manner as the Kyoto targets, which specified the emissions budget of each country in precise numerical terms (as a function of emissions in a base year), and allocated each country emission allowances based on its target. In contrast, some developed countries (including the United States) have suggested a more bottom-up approach, under which new emission targets would be tied to a country's national climate change legislation, which could define the exact coverage and accounting of the country's target as well as the types of credits that could be used to satisfy it. Under this approach, compliance would be assessed, not in terms of whether a country's emissions were within its international emissions allowance budget, but in terms of whether a country's emissions satisfied its target, as spelled out through its national climate change legislation.

Market mechanisms / Emissions Trading

The Kyoto Protocol establishes an international emissions trading system, pursuant to which countries can trade international emissions units (including both allowances and credits) through an international registry.

Reportedly, both the US and the EU may prefer, in a new climate regime, a system of interlinked national trading programs rather than a single international trading system. Under this approach, international emissions trading would occur, not under the international agreement itself, but pursuant to whatever bilateral arrangements countries negotiated among themselves. If such an approach were adopted, this would mean that, even if a country such as Rwanda adopted an emissions target, it would not automatically be able to trade with other countries. Instead, its ability to trade would depend on negotiating bilateral agreements with other countries.

Whether or not emissions trading under a new climate change agreement occurred primarily pursuant to national legislation or under the international agreement itself, developed country parties such as the US and the EU are still likely to recognize internationally-approved credits resulting from developing country emission reductions, such as those created under the CDM. If so, CDM credits may prove to be more easily marketable internationally than the emission units created by a national emissions target (which, as discussed above, might be tradable only pursuant to bilateral agreements). To the extent that developing countries wish to reap benefits from the international carbon market, CDM reform may thus be a more promising vehicle than the adoption of a national emissions target.

Thus far, the CDM has resulted in relatively few projects in small, less-developed countries. Given the high costs of getting projects approved, CDM projects tend to be cost-effective only if they promise large emission reductions. In reforming the CDM, the highest priority for small developing countries is to develop a simpler crediting mechanism, which would make it possible for them to receive credits for their emission reduction actions. Possible reforms include crediting of policy measures (policy-based CDM) and crediting on a sectoral level (for emission reductions below a BAU baseline or sectoral benchmark). In order to reward a developing country such as Rwanda for its existing policies to limit emissions, emissions reduction credits could be calculated based on benchmarks (developed on a sectoral basis or for similarly-situated countries) rather than based on business-as-usual projections for the individual country itself.

Developing country actions and commitments

Thus far, most of the attention in the negotiations has focused on nationally-appropriate mitigation actions by developing countries, which could be included by a country in an international registry and subject to measurement, reporting and verification. Important issues include:

- the degree to which internationally-registered NAMAs would receive international support,
- whether internationally-supported NAMAs would be subject to additional requirements (for example, regarding measurement, reporting and verification)
- whether emission reductions resulting from NAMAs could receive international credits (and, if so, what additional requirements this would entail).

Some proposals made by developed countries in the AWG-LCA contemplate further mitigation commitments by developing countries. These could potentially take the form of emission targets or policies and measures. In general, the focus of this discussion has been on new mitigation commitments by the major economies (such as China, India and Brazil), which account for a significant share of global emissions and whose participation in the regime is essential to achieve global stabilization objectives, rather than on new mitigation commitments by smaller developing countries or by the least developed countries.

Some developing countries, in particular India, have suggested a system of per capita emission targets. Although, in the longer-term, per capita emission targets would provide significant benefits for countries with low per capita emissions, such as Rwanda, there is no prospect of this approach being adopted in Copenhagen.

Financial support

The financial provisions of a new agreement (or decision of the parties) are still wide open. One critical issue is whether new financing will depend on national appropriations (as is the case with most development assistance) or will be generated automatically, for example, through a set aside of national emission allowances or through a levy on the international trading mechanisms (as is the case with the adaptation fund, which is generated by a share of the proceeds of the CDM). In general, mitigation financing will likely be directed, primarily, to actions and projects that promise the biggest emission reduction for the dollar. As a result, countries whose projected emissions are already low and that have comparatively low mitigation potential stand to gain less financing than countries with greater mitigation potential.

Additional Issues

Institutional Issues. Realising credits involves more than just having low carbon projects available. The potential is strongly linked to the ability to demonstrate additionality, to have necessary institutional organisations in place (designated national authority), to be able to verify and get audited, and increasingly, to provide a good investment environment, to attract investors, given the large global opportunities for developers. There is a need to investigate what is required to provide the necessary institutional environment and attractions to let Rwanda be an early beneficiary of direct carbon investment in Africa, early REDD and early adaptation funds.

Size of potential credits. The potential flow of carbon credits to Rwanda is extremely small, because of the small size of the existing energy sector and national emissions. Total emissions from electricity are only 327 Gg (0.33 Million tonnes) of CO_2 in 2020. This is only likely to provide small marginal finance flows. Even the entire energy sector, with emissions at 3555 Gg in 2020, or total national emissions, only represent a small potential market. To put this in context, a large single project in China would actually involve higher carbon flows.

We believe the small-scale negates the realistic entry of an innovative approach into the formal mechanisms, or the development of new mechanisms for Rwanda alone, because the transaction and legal barriers would be too high for such a small scale. However, this might be possible through a co-ordinated approach (e.g. amongst LDCs), or through other mechanisms that set out to reward lower carbon trajectories

An alternative policy, that might be able to attract additional finance flows, would be to target alternative climate financing, particularly future adaptation funds (or plausibly REDD). A potential feature of adaptation funds will be to ensure adaptation-mitigation linkages and it might be possible to link sustainable growth plans with low carbon growth and adaptation.

There are also voluntary carbon market opportunities which could offer more flexibility and may be suitable for Rwanda. Indeed, there are already ongoing projects in the country (sustainable, low-carbon, agro-forestry and land-use management). These projects have strong adaptation-mitigation linkages, in addition to sustainable livelihoods benefits.

6) Recommendations for Policy

Based on the study findings, we make the following recommendations.

1. The study finds very real economic, environmental and social benefits to Rwanda from adopting a low carbon development path, and we would recommend a strong continued commitment to such a policy. Rwanda is already advancing low carbon initiatives in many areas and provides a pioneering example of the practicality and benefits of such policy.

2. While it would be possible to set some form of target as a further political commitment to this low carbon pathway at the Kigali meeting, we do not recommend this at the current time. The primary reason for Rwanda to set a target is to maximise the potential for carbon credits and investment flows under current or future mechanisms. Announcing an early target in advance of the outcomes of the negotiations is likely to constrain future options for Rwanda.

3. This point is further reinforced by the current uncertainty around Rwanda's national emissions and growth path. Based on this very quick study, we do not believe it is possible to estimate the future emissions baseline - and the carbon reduction potential for Rwanda - to a degree of confidence that would allow a political target and announcement.

4. While some reforms or even new mechanisms will be more favorable for Rwanda than others, we do not believe that Rwanda (on its own) can introduce or shape the future mechanism that will emerge - and is more likely to be successful in gaining advantageous changes as part of a common African position. We would encourage engagement with the African Group of negotiators towards this, as well as collaborative regional action.

5. There is a large need for adaptation finance for Africa and Rwanda, and entitlement to substantial funds through the Adaptation Fund must be assured. This will be helped through a common negotiating position. However, accessing any funds will require the development of effective mechanisms and institutions within Rwanda. There is a need to consider the linkages between adaptation and low carbon pathways, and exploit the opportunities that arise from considering them together.

6. Following from the points above, we believe it would be extremely beneficial for Rwanda to undertake an early and detailed assessment of a low carbon strategy and adaptation assessment before Copenhagen. This would consider the analytical underpinnings that will feed into a national low carbon development plan. It would also be advisable for Rwanda to strengthen its capacity to develop and implement proposals for specific NAMAs and adaptation funding that might usefully be undertaken in Rwanda. Taking this action would address the issues raised above. More importantly it would give Rwanda a first mover advantage to act quickly, and to seek funding for this plan, through whatever negotiating positions and mechanisms emerge.

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