SEI STOCKHOLM ENVIRONMENT INSTITUTE

Economics of Climate Change in Rwanda

2009

Summary and Key Messages

This study has assessed '*the Economics of Climate Change in Rwanda'.* It was funded by DFID and undertaken by the Stockholm Environment Institute (in Oxford) working with local partners. It covers:

1. The impacts and economics costs of climate change;
2. The costs of adaptation; and
3. The potential for low carbon growth.

The study has advanced a number of approaches to investigate these areas, using aggregated analysis (top-down), sector assessment (bottom-up) and case studies. The key messages are presented below.

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1. The Economic Costs of Climate Change Impacts in Rwanda

Existing climate variability has significant economic costs in Rwanda.

Periodic floods and droughts (extreme events) already cause major socio-economic impacts and reduce economic growth in Rwanda. Major flood events occurred in 1997, 2006, 2007, 2008, and 2009, where rainfall resulted in infrastructure damage, fatalities and injuries, landslides, loss and damage to agricultural crops, soil erosion and environmental degradation. In some regions of the country there have also been periodic droughts, for example in 1999/2000 and 2005/6.

The study has undertaken case studies and surveys to investigate recent flood events. A study of the Nyabugogo River Plain found that flood damages occur each rainy season, which lead to direct (damage) and indirect effects, particularly to informal settlements. The second case study in Bahimba Valley reports that the 2005 flood damaged crops, bridges and led to environmental degradation. The final case study, in the Nyabihu Musanze and Rubavu districts, reports that the 2007 floods led to fatalities, agricultural losses, building and infrastructure damage and population displacement.

The impacts of these events are economically significant. The most severe of the recent events was the 2007 flood. The study has estimated that the direct measurable economic costs of this event were $4 to $22 million (equivalent to around 0.1 – 0.6% of GDP) for two districts alone. However, this only includes the direct economic costs of household damage, agricultural losses and fatalities. It does not include the wider economic costs from infrastructure damage (including loss of transport infrastructure), water system damage and contamination, soil erosion and direct and indirect effects to individuals.

The total economic costs of the 2007 floods are therefore much larger and would increase further when other national level effects are considered. It is clear that these events have economic costs that would be very significant in terms of national GDP. The continued annual burden of these events leads to reductions in growth over time.

Floods 2007 in Bigogwe, northern Rwanda
(Rose Mukankomeje, REMA)

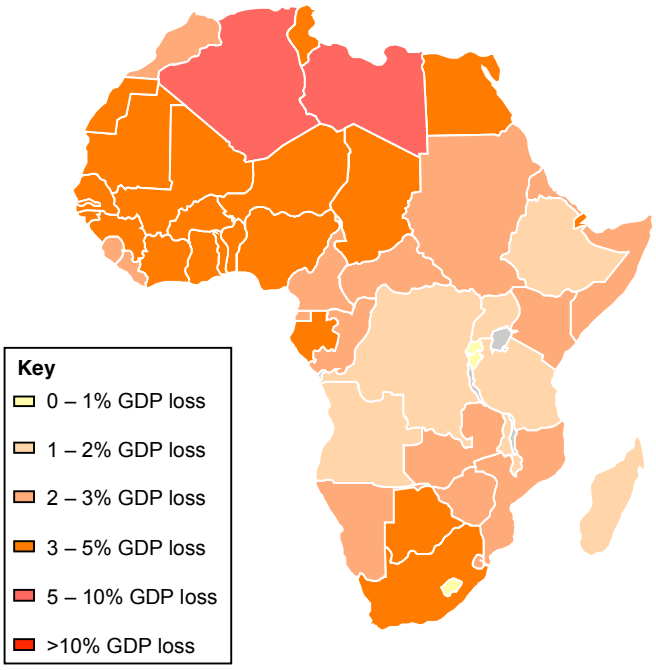
There are also wider impacts from the current climate. The study has found some indication that recent temperature trends may have shifted the altitudinal pattern of malaria and raised the national burden of malaria in recent decades (increasing preventative and treatment costs). Some of these recent trends (e.g. temperature

shifts, climate variability and flood intensity) may reflect an already changing climate. However, any impacts also have to be seen in the context of changing patterns of vulnerability over time.

The implications of these findings are that Rwanda has a current adaptation deficit, i.e. it is not adequately adapted to existing climate risks.

<u>Future</u> climate change will lead to additional economic costs.

Africa is predicted to have greater impacts than other world regions, because of higher vulnerability and lower adaptive capacity. Impacts could threaten past development gains and constrain future economic progress. Some regions and populations in Rwanda have very high vulnerability.



The Economic Costs of Climate Change in Africa
(Source: FUND Model)

The future economic costs of climate change are very uncertain. However, aggregate models indicate that the <u>additional</u> net economic costs (on top of existing climate variability) could be equivalent to a loss of almost 1% of GDP each year[1] by 2030 in Rwanda, though this excludes the future effects of floods and other extremes. This estimate is therefore considered a potential lower bound.

In the longer-term, after 2050, the economic costs of climate change in Africa are expected to rise, potentially very significantly. However, the aggregate models report that global stabilisation scenarios towards a 2ºC target could avoid the most severe social and economic consequences of these longer-term changes. This emphasises the need for global mitigation, as well as local adaptation.

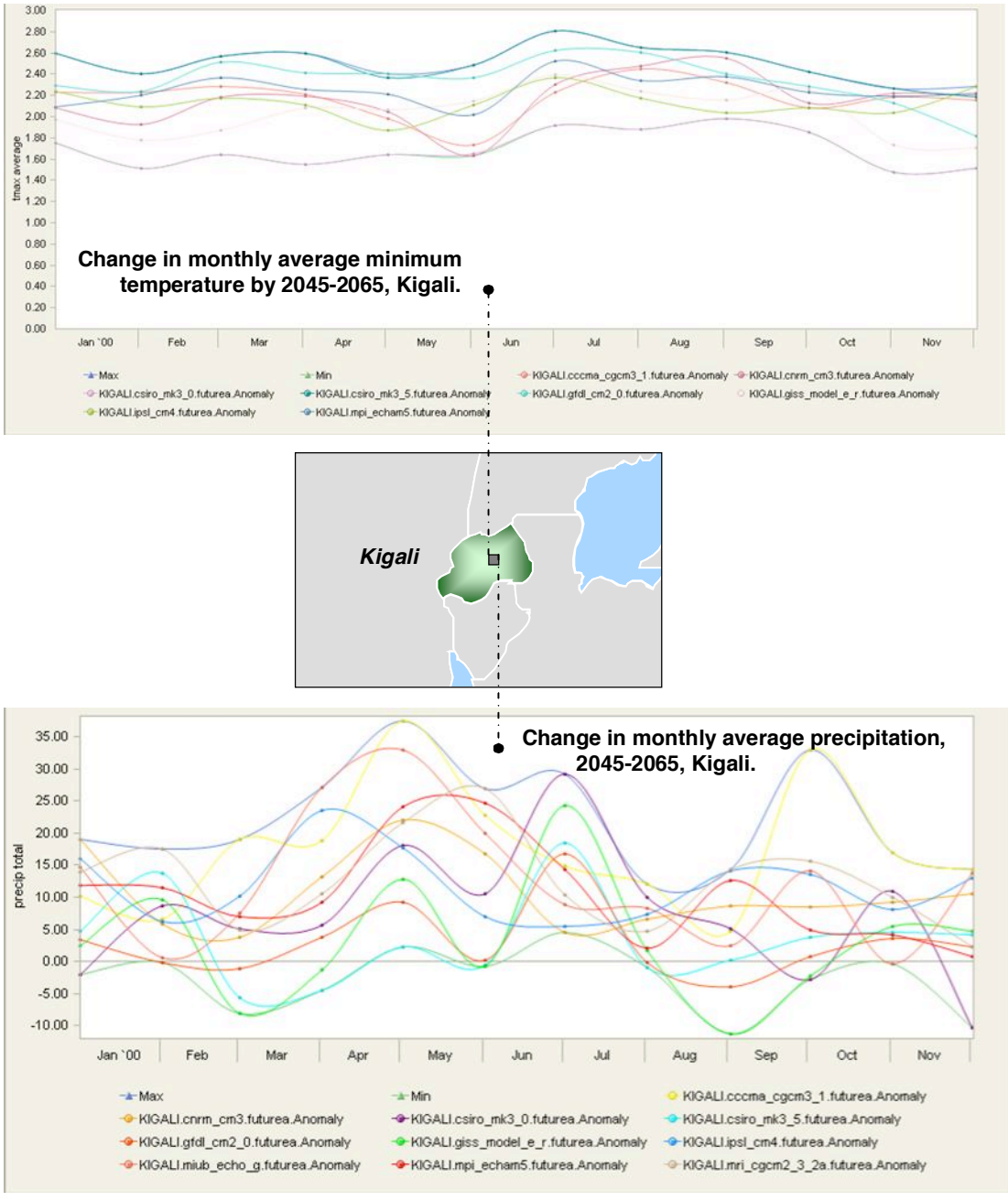
The study has also undertaken bottom-up assessments of the impacts and economic costs of climate change for a number of sectors, working with climate and socio-economic projections. Rwanda already has a complex existing climate, with wide variations across the country and very strong seasonality, though it is more temperate than much of East Africa. It has two wet seasons, and has strong patterns of climate variability and extremes, not least due to the periodic effects from the El Niño – Southern Oscillation (ENSO) and La Niña, which are associated with extreme rainfall and flooding and droughts (respectively) in the region.

The study has considered projections of future climate change from a suite of downscaled global models for Rwanda, though geographical dis-aggregation has been limited by data availability. The projections indicate future increases in mean annual temperature (average monthly temperatures) of broadly 1.5 to 3 ºC over the range of models by the 2050s (2046 - 2065). The changes in precipitation are more uncertain. All the climate models show that rainfall regimes will change and the majority indicate an increase in average annual rainfall (with a central value of typically 10%), particularly in September to November, indicating a potential strengthening of the rains. However, some models project reductions in some months.

[1] Central net values (sum of positive and negative) for market and non-market effects. The results exclude future extremes (floods & droughts) and do not capture a large range of potential effects including all ecosystem services.

The information on extreme events (floods and droughts) is much more variable. While there is some evidence of a recent intensification, the future projections vary widely. Nonetheless, many models indicate an intensification of heavy rainfall in the wet seasons, which is particularly important in relation to a greater flood risk.

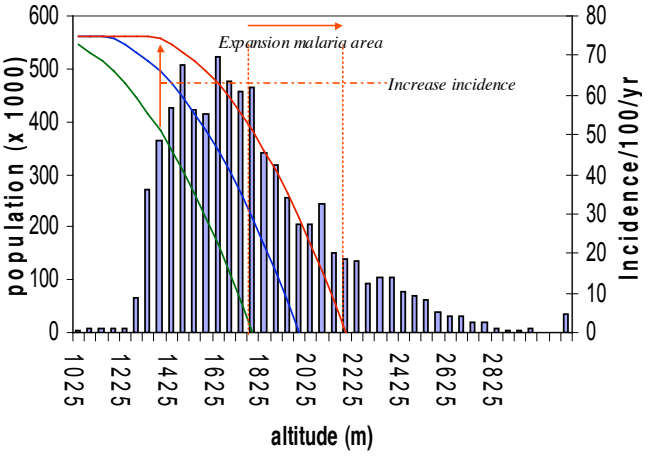
The range of model results highlights the considerable uncertainty in predicting future effects, especially in relation to scenarios of future rainfall, floods and droughts, though also due to future socio-economic conditions and environmental services. Nevertheless, the analysis here does reveal potential areas of concern and helps focus priorities.



Climate projections for Rwanda
Source CCE

Furthermore, it is essential to recognise this uncertainty, not to ignore it. There is a need to plan robust strategies to prepare for uncertain futures, rather than using uncertainty as a reason for inaction.

In the absence of adaptation, the study estimates that there could be a potentially large increase in the health burden of malaria in Rwanda. This arises because a large part of the rural population lives at higher elevations, where the disease is currently restricted by temperature. The study has applied a new malaria risk model, based on altitude, and finds that climate change could increase the rural population at risk for malaria by 150% by the 2050s.



Malaria Risk model for Rwanda

The increase in the disease burden is significant and could lead to full economic costs that are over fifty million dollars/year. These effects are raised as a future priority area for consideration (further research and early action, see recommendations). The study also identifies other possible direct and indirect health effects from climate change.

In the agricultural sector, the net economic effects vary with the range of climate projections and the analytic models used. Under some futures and with certain models, modest impacts on agriculture are predicted in the medium term (with some regions even experiencing increased agricultural yields). However, under other scenarios and other models there are economic costs projected for the sector. A range of additional factors are also important, which are not included in these assessments, including the effects of extreme events, pests and diseases, etc. The range of potential effects and the high importance to the economy and livelihoods mean that this sector is a priority for future consideration (further research and early actions).

Even in the absence of climate change, the economic costs of the periodic floods that affect Rwanda could rise significantly in future years, due to socio-economic change (population and economic growth). The study has assessed these changes and finds that in the absence of adaptation, these drivers could increase the costs of events by a factor of five by 2030, i.e. a periodic large-scale regional event similar to the 2007 flood could have direct economic costs of up to one hundred million dollars (though events of this size are infrequent). A key priority therefore is to increase the resilience of Rwanda to cope with these extreme events. Climate change is likely to further increase the economic costs of these events. Many of the projections indicate a change in heavy precipitation events for Rwanda. A number of models suggest a 10% increase in intensity for 1 in 10 year and 1 in 100 year rainfall events (though other projections indicate increases of 50% for 1 in 10 year events).

These increases in intensity would increase the economic costs of periodic flood events significantly, because of the non-linearity in the costs with flood depth and strength. They would also mean a reduction in the return period of larger events, i.e. more significant floods would occur more frequently. Even when annualised, these indicate significant increases in economic costs. The effects on droughts are more uncertain, but the range of model projections does include changes that would exacerbate existing periodic events for some regions of the country.

The study has investigated additional issues with energy supply and demand. For the energy sector, the relatively high level of hydro generation in the Rwandan electricity mix might increase future vulnerability under a changing climate, though the main trends in the

projections indicate the primary concern would be for coping with more extreme events (greater rainfall intensity). It is noted, however, that future land-use patterns will also be important in influencing future hydro potential. Similarly, the trend in average temperatures will increase the number of hotter days and potentially increase the cooling burden in urban areas, important in relation to building comfort levels and equipment (including I.T.). However, analysis across the range of model projections shows effects are likely to be modest even by the 2050s, due to the existing temperate climate.

Finally the sectoral analysis has considered ecosystem effects. Rwanda has exceptional biodiversity. These ecosystems provide multiple benefits to society, which in turn have economic benefits, though these are rarely captured by markets. These benefits are known as 'ecosystem services' and include provision of food, supporting services, regulatory services including flood protection and recreational and cultural services. The study has mapped the potential ecosystem services in Rwanda and considered (qualitatively) the potential additional pressures from climate change.

The study finds that ecosystem services are integral to the Rwandan economy and underpin over 50% of Rwandan GDP, as well as sustaining a very large proportion of the population. There are many stresses on these systems already and climate change will add to these pressures. These potential effects are also highlighted as an early priority area.

The study has undertaken a number of case studies to provide more detailed local analyses. This has included the consideration of flood events, vulnerable groups and iconic ecosystems (including the Mountain gorillas).

Overall, the bottom-up analysis indicates that in the absence of adaptation, the aggregated estimates of economic costs - which occur on top of the existing effects of climate variability - could potentially be very large. Detailed analysis for a single burden (malaria) in a single sector (health) indicates that future economic costs could be over fifty million dollars a year by the 2050s. There are also potential effects on ecosystem services, which whilst difficult to estimate in economic terms, could be just as important. The analysis of future costs of extreme events indicates that large increases in the economic costs of these events will occur over the same period. Finally, there are some possible scenarios of climate change on the agricultural sector which would lead to high economic costs and have very significant effects on rural livelihoods.

Overall, the bounded range of economic costs could potentially be very large, in terms of the equivalent costs to GDP. There is also likely to be a strong distributional pattern of effects, with some sub-regions and some groups affected more than others.

The Economics of Adaptation in Rwanda

Adaptation can reduce the economic costs of climate change but it has a cost. The costs of adaptation are still emerging and as they follow from impacts, these too are uncertain. However, this does not mean that no action should be taken. Instead it requires more robust strategies.

The study has investigated the top-down aggregated estimates of the costs of adaptation. This has used estimates for Africa/East Africa and scaled these to Rwanda. Four categories of adaptation have been identified. Two of these are development activities and are targeted towards the large economic costs of current climate variability. They are 1) addressing the current adaptation deficit and 2) increasing social protection. The second two are associated with tackling future climate risks and are 3) building adaptive capacity and 4) enhancing climate resilience. The overall costs of adaptation vary according to which of these categories is included.

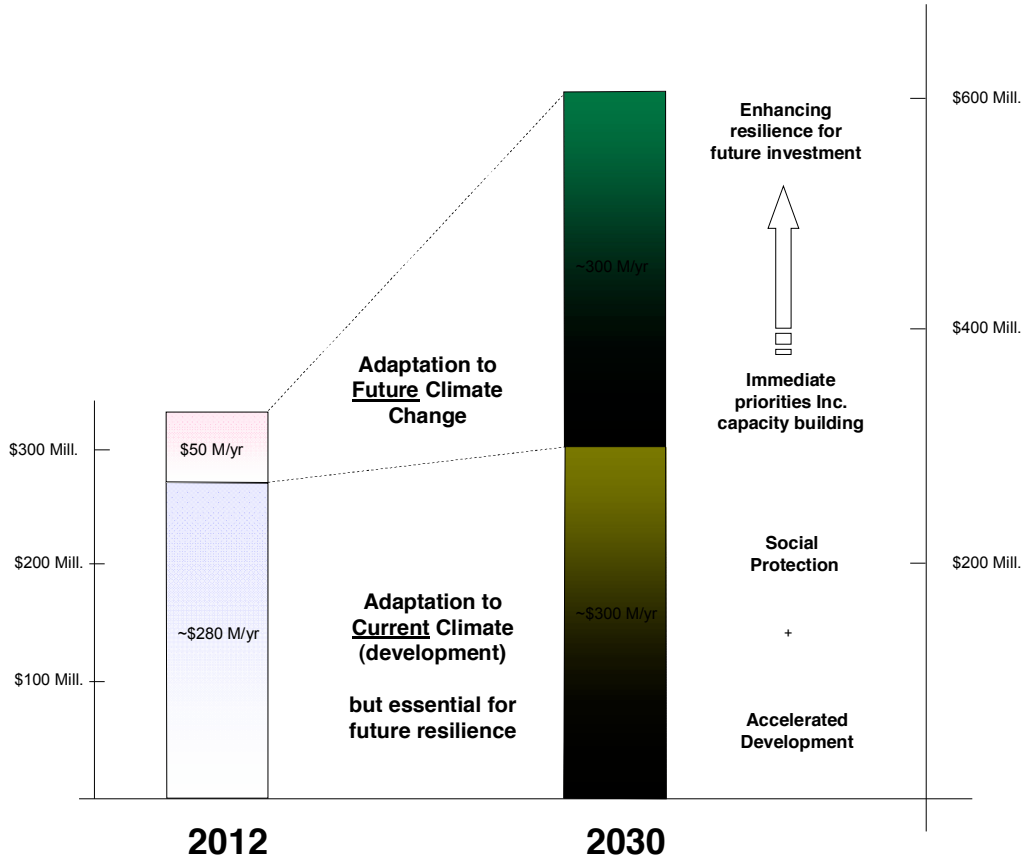
The immediate needs (for 2012) for building adaptive capacity and addressing early priorities requires a significant scaling up from the current NAPA estimates ($8 million), estimated at $ 50 million/year. However, a much higher value of approximately $ 300 million/year is warranted if the categories of social protection and accelerated development (to address the current adaptation deficit) are included. As highlighted above these categories are associated with

current climate variability – such as the existing vulnerability to floods - and are therefore associated with development, rather than with future climate change. However, investment in these areas provides greater resilience for future change and they are essential in reducing future impacts.

The estimated costs of adaptation will rise in future years. The aggregated estimates provide a possible range, with implications for the source and level of finance required. Estimates of medium-term costs to address future climate change are typically of the order of $50 – 300 million per year for Rwanda by 2030, focused on enhancing climate resilience. Note that the investment in 2030 builds resilience for future years when potentially more severe climate signals occur. However, higher values (in excess of $600 million /year) are plausible if continued social protection and accelerated development are included, noting that these are primarily development activities.

The study has also assessed the costs of adaptation for Rwanda using a sectoral bottom-up approach, to test the estimates above and to give greater insight into sectoral planning. The study has advanced a framework to prioritise early adaptation in the sectoral analysis, which considers uncertainty within an economic framework. This identifies early priorities of:

- Building adaptive capacity;
- Focusing on win-win, no regret or low cost measures (justified by current climate conditions or involving minimal cost);
- Encouraging pilot actions to test promising responses; and
- Identifying those long-term issues that require early pro-active investigation (though not necessarily firm action).



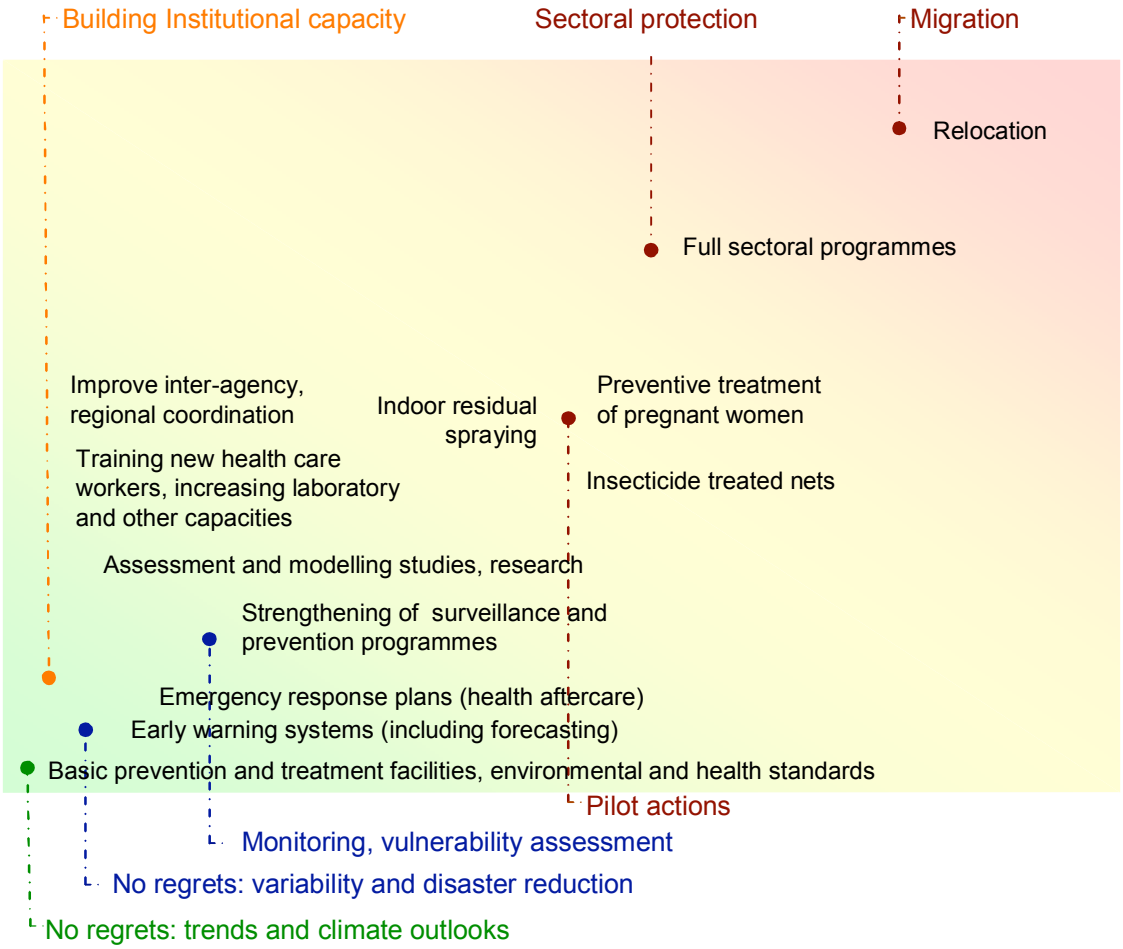
Potential Costs of Adaptation to Current and Future Climate in Rwanda $Million per year

A series of 'adaptation signatures' have been developed to identify actions in each of these four categories for each sector. The broad outline of steps (as above) is the same in each sector. However, the exact activities vary, hence the use of a 'signature' concept that considers options on a case by case basis. These signatures have been to develop indicative adaptation costs for the health, water and agriculture sectors. These have been complemented by case studies which include examples of adaptation projects and costs.

In the health sector, the potential costs of adaptation to address the potential increasing burden were considered based on treatment and prevention costs. An example of the adaptation signature is shown below.

In the water sector, water resource investments were assessed across sectoral activities to identify areas for climate resilient development and adaptation mainstreaming, based on the Rwanda's NAPA and EDPRS recommendations for integrated water resource management (IWRM), as well as 2009/10 public expenditures and MTEF projections. In the agricultural sector, estimates are provided to illustrate the scale of effort that may be required and some of the urgent priorities.

A large number of immediate priorities areas and no regrets options have been identified from these assessments. As examples, they include the strengthening of effective surveillance and prevention programmes for health linked to enhanced meteorological systems and similar strengthening programmes in other areas (e.g. expanded monitoring of key ecosystems).



An Adaptation Signature for Health

They also include capacity building to strengthen the meteorological analysis and forecasting for seasonal outlooks (agriculture) and extreme events (flood risk), with the latter linked to the strengthening and development of early warning and disaster risk reduction, as well as risk mapping and basic screening in planning. Finally, they include pilot actions across all sectors and for promising options (e.g. terracing, malaria prevention) the potential scaling up of sectoral programmes.

The sectoral assessments and the case studies show relatively high adaptation costs, which confirm the lower end of the adaptation estimates for 2030 above and justify investment needs. They also demonstrate the potentially much larger costs when development-adaptation needs are included. The studies demonstrate that adaptation has very large benefits in reducing present and future damages.

Terraces in Kisaro

However, while adaptation reduces damages, it does not remove the impacts of climate change entirely. Residual impacts in Rwanda, particularly for some regions and groups of society, will need to be considered. They will also be important for recovery after climatic disasters and for future impacts. It is highlighted that the costs of adaptation are only part of the full costs of climate change: both adaptation costs and residual effects are important for international negotiation discussions.

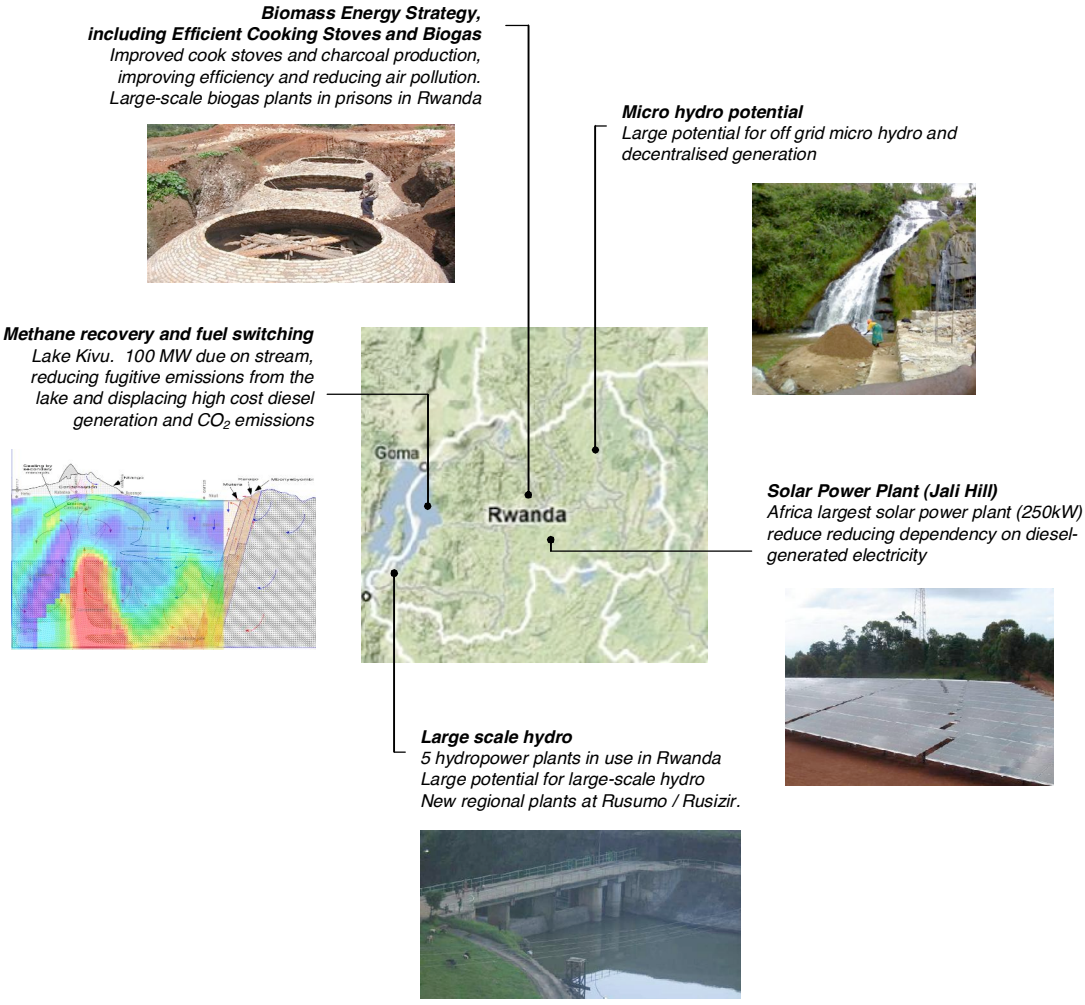
Finally, while there is a large need for adaptation finance, and entitlement to substantial funds must be assured, accessing these funds will require the development of effective mechanisms and institutions. There is a need for Rwanda to agree on next steps, the future focus and to build capacity, including national and sectoral planning objectives, enhanced knowledge networks and verifying outcomes of adaptation strategies and actions.

Low Carbon Growth in Rwanda

The analysis has first considered the current emissions in Rwanda. These show that the country currently has relatively low emissions of greenhouse gas emissions (total and per capita). Moreover, Rwanda has already introduced a range of low carbon options across many sectors (see below.

The study has then considered the potential change in emissions consistent with planned development in the Vision 2020 plan and developed a future emissions profile for Rwanda. This projects that the strong growth planned in the Vision document, as well as other changes from population and urbanisation, will increase future total and per capita GHG emissions significantly, even though Rwanda is initiating policies that are consistent with low carbon development.

Under the future 'business as usual' development scenario, the study estimates that total emissions of greenhouse gases will double between 2005 and 2020. These future increases are driven by the transport and agriculture sectors, which are likely to become the dominant sources of future emissions. However, even in the electricity sector, which currently has a high share of renewables (hydro), the plans for the development of Lake Kivu would start to increase the absolute emissions from electricity generation in the short-term and potentially increase the carbon intensity of the entire Rwandan generation mix in the medium term.



Existing Low Carbon Projects in Rwanda

Following these higher carbon pathways will therefore lead to an opportunity loss for Rwanda. They could also lead to other economic, social and environmental costs: an example would be the congestion, higher fuel costs, greater fuel imports and higher air pollution that would occur if private car use grows rapidly in Kigali.

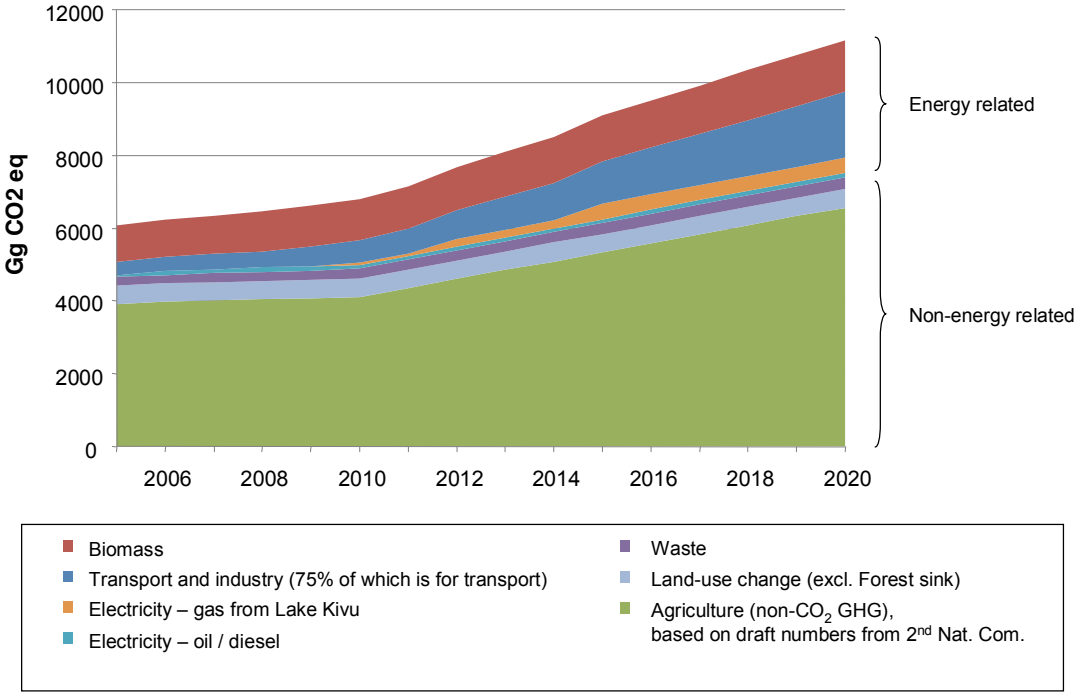
The current plans across the economy (or for some sectors, the lack of plans) could 'lock-in' Rwanda into a higher emission pathway. The increases from the transport, agricultural and electricity sectors, and the associated increase in national emissions, would occur at exactly the time when there are likely to be greater economic opportunities for carbon credits and markets, particularly if national level mechanisms emerge.

The study has therefore investigated low carbon options across the economy, developing a low carbon alternative pathway. This shows that there are a large number of 'no regrets' options, particularly from improvements in transport efficiency, domestic stoves and agriculture, as well as for the electricity sector, which would enhance economic growth, as well as allowing further access to international carbon credits.

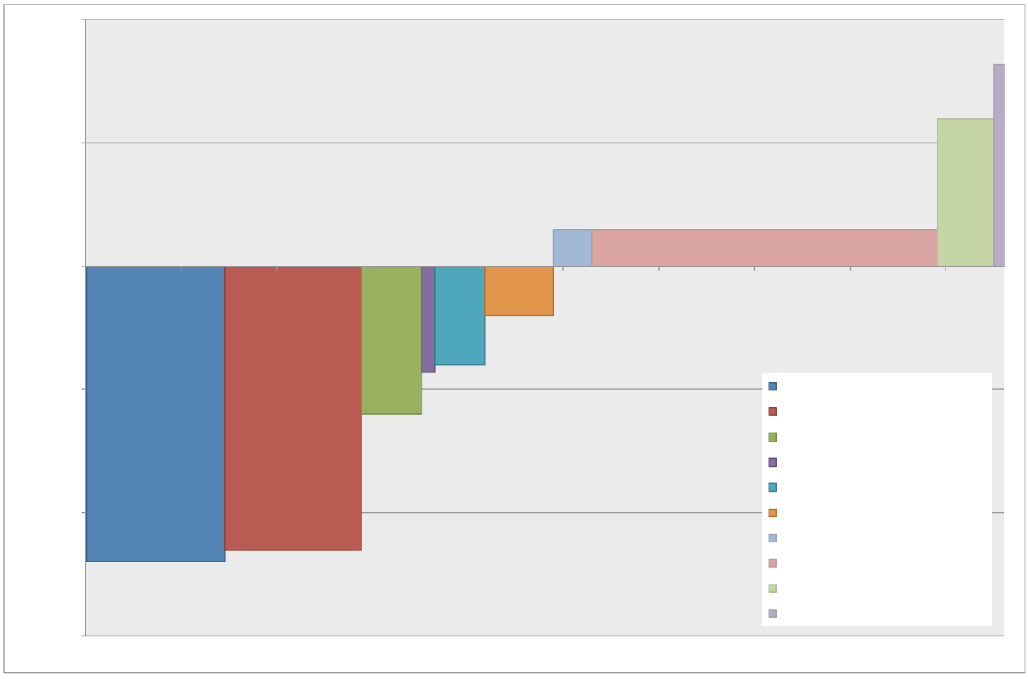
These options produce significant emission savings and can be realized at negative cost, i.e. the economic benefits outweigh the costs. An example would be with an energy efficiency measure that actually saves the individual or company money (e.g. from reduced fuel costs) when compared to the current baseline. These options also have wider economic benefits from

greater energy security and diversity, reducing air pollution and environmental impacts. The study has evaluated the emission reduction potential from such options, for a number of potential sectors, and compared this against the 2020 baseline.

This finds that large-scale national emission reductions could be achieved under a scenario which would also be economically advantageous. The study also highlights the need to widen this analysis and to develop a longer term strategy beyond 2020.



Emission projections for Rwanda



Indicative marginal abatement cost curve (energy) for Rwanda

Recommendations

The study has outlined a number of recommendations and future priorities.

This needs to consider how the international action by developed countries to address climate change might affect Rwanda, notably in relation to its planned economic growth in areas such as tourism, exports, etc. as well as considering how best to co-ordinate co-operative regional (East African) responses.

Further work is needed to improve these initial estimates and to give a degree of confidence in the analysis.

- Such as follow-on phase might include a broader (and for key priorities, a deeper) analysis by sector, particularly for health burdens, agriculture, water/flood risks and ecosystem services.

- This would need to be accompanied by a more systematic adaptation assessment, with estimates of costs, focused on short- and medium priorities at a sectoral (and cross-sectoral) level.

- On the low carbon side, it would be useful to undertake a more comprehensive analysis of potential opportunities, with marginal abatement cost curves and consideration of priorities across all sectors.

- This would provide both adaptation and low carbon costs in detail, and as part of an investment and financial flow analysis (by sector), it would establish the potential additional funding needs above the current development baseline. This would provide a firm basis for increased future funding. Taken together, this follow-on analysis could form the basis of a new strategy.

There are a number of urgent priorities for building adaptive capacity in Rwanda that should be fast-tracked, notably in relation to meteorological monitoring, forecasting and information (as these underpin future prediction and analysis) and early warning systems, as well as information provision, monitoring (indicators) networks and focal points. The early priorities also include increasing the knowledge base, education and training and strengthening existing programmes.

There is also a need to build future climate change risk screening into development and planning, at a sectoral and regional level. Information on climate, resources and adaptation strategies and options should be mainstreamed into all sectoral plans.

- To enable this, the study recommends that a national knowledge management system be developed; with easy access by all stakeholders to compile more detailed databases of potential climate risks across all areas of the economy.

Access to substantial adaptation funds must be assured. However, mechanisms and institutions for effective use must be developed to allow Rwanda to access these funds. This requires early and concerted action to build capacity across stakeholders and with the affected communities themselves. This is an early priority.

- To progress this, some form of national adaptation authority should be set up to assess the potential for climate resilient growth across all areas of the economy and to mainstream adaptation into government departments and with Rwanda's development partners. There is also a need to encourage the linkage between national adaptation and low carbon action (the latter including the designated national authority).

There are many benefits if Rwanda switches to a lower carbon pathway. However, this will not happen on its own and steps are needed to realise these benefits and to maximise the potential flow of carbon credits under existing and future mechanisms.

Low carbon plans should extend beyond the power generation sector. This will necessitate a greater focus on transport and agriculture.

There is a particular need to consider areas of development that might 'lock-in' Rwanda into higher emissions pathways, notably in the energy, transport and urban environment. It

would be useful to specifically address these threats and to identify alternatives.

All future development and planning, including low carbon investment, should consider future climate change, which necessitates climate risk screening in future low carbon plans across all sectors. Potential linkages between adaptation and low carbon development (especially in finance) should be explored.

The planned revision of the EDPRS should examine the potential effects of climate change and the potential for adaptation and low carbon growth – and this should also extend to forthcoming revisions of PRSP and other studies. There is also a need to build on existing government and donor activities (such as the environmental sector working groups). In the longer-term, there is a need to develop a new strategic vision for Rwanda that addresses these areas, for example, with the revision of the Vision 2020 document, including both domestic and international aspects.

The steps above would provide national action on a low-carbon, climate resilience investment plan and would establish Rwanda as an international leader, with the 'first mover advantage' in negotiations and securing finance.

Finally, the potential for a more radical policy shift is also highlighted as an option for Rwanda. Because of the level of current development and the importance of near-term decisions in determining the long-term economic and social structure of the country, it might be possible to truly promote a visionary approach to low carbon development and climate resilient growth within the context of environmental sustainability and economic growth, i.e. to set a new model for Africa. This would position Rwanda internationally along a very progressive vision, consistent with the recent Presidential statements on climate change and adoption of green technology.

Key priorities for adaptation and low carbon growth are outlined below.

Adaptation Strategies	Priority Actions
Immediate needs & capacity building	• Expanded research assessment into effects, adaptation and economics. Early capacity building, e.g. meteorological data/systems and early warning systems • Develop national climate change strategy including knowledge management and screening of sectoral and regional plans for climate risks and adaptation opportunities. Include in EDPRS revision. Build into long-term vision (e.g. next Vision 2020) • Prepare plans for a national adaptation authority to improve sectoral coordination, link to international finance, and support private sector. Enhance links between adaptation and low carbon.
Climate resilience	• Develop climate resilience strategies for immediate concerns (e.g. cross sectoral meteorological systems, information and forecasting, health and malaria monitoring and actions, flood risk screening) • Develop prototypes of sectoral actions (pilots) and pathways for scaling up to cover all vulnerable regions and populations
Social protection	• Protect vulnerable livelihoods and strengthen existing social protection programmes, expanding the coverage to consider climate change.
Accelerated development	• Adapt existing development projects to include 'no regret' measures to reduce climate risks and opportunities to develop adaptive capacity • Scale up successful prototypes to sectoral development plans

Mitigation Strategies	Recommended Actions
Low-Carbon Growth (LCG)	• Full analysis of low carbon options, costs and potential for prioritisation and development of strategy for mechanisms. • Develop national strategies to mainstream LCG in planning, including a revised EDPRS and possibly new Vision. • Facilitate carbon finance opportunities in voluntary and compliance carbon markets (VCM, CDM) • Prioritize agriculture, transport and electricity generation low carbon measures, considering short-term opportunities but also longer-term areas where potential 'lock-in' and identify alternatives. Improve sectoral co-ordination. • Look for synergistic adaptation – low carbon project opportunities, e.g. agro-forestry and sustainable land-use
Climate resilience & co-benefits	• Climate risk screening of low carbon growth pathways • Consider opportunities to achieve robust development, e.g. in planning hydropower (large reservoirs, small in-stream turbines), biofuels, on-farm carbon management (e.g. zero grazing, woodlots)

Project Description and Project Team

The project has been funded by DFID, the UK Department for International Development.

The **Stockholm Environment Institute** (SEI Oxford Office) led the study. SEI is an independent, international research institute, engaged in environment and development issues at local, national, regional and global policy levels. The SEI has a reputation for rigorous and objective scientific analyses of complex environmental, developmental and social issues. The Oxford office leads development of the weADAPT.org platform, managed by the Global Climate Adaptation Partnership (www.ClimateAdaptation.cc).

This study was commissioned under DEW Point, the DFID Resource Centre for Environment, Water and Sanitation (Bruce Mead) which is managed by a consortium of companies led by Harewelle International Limited. The project team included.

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- IGAD Climate Prediction and Applications Centre (ICPAC).
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- London School of Hygiene and Tropical Medicine: Menno Bouma and Sari Kovats.
- ILRI: Joseph Maitima, Simon Mugatha, Patrick Kariuki.
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Full project reports
More detailed technical annexes to support this document are available on the project website: http://rwanda.cceconomics.org or http://rw.cceconomics.org/

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We acknowledge the valuable contributions of many people and organisations. Although the study was commissioned by DFID, the views expressed in this brief are entirely those of the authors and do not necessarily represent DFID's own views or policies, or those of DEW Point.