REPUBLIC OF RWANDA

Rwanda Environment Management Authority (REMA)

GUIDELINES TO MAINSTREAM CLIMATE CHANGE ADAPTATION AND MITIGATION IN THE ENERGY AND INFRUSTRUCTURE SECTOR

FINAL DRAFT

Building a Climate Resilient Infrastructure and Energy Sector for Rwanda

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BREAKING COMPLEXITIES IN DECISION MAKING

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Foreword

Rwanda has come a long way on its Vision towards a medium income country by 2020, with major achievements made in all sectors. However, climate change, a major global phenomenon with serious local implications, threatens to undermine the achievements. Although Rwanda in particular and Africa in general, have contributed very little to global warming, they will be disproportionately impacted by climate change. Rwanda's natural resources are particularly vulnerable because of the high pressure of exploitation they are exposed to, the fragility of ecosystems and low levels of technological innovation. The good news, however, is that adaptation measures can reduce the country's vulnerability and significantly lower the costs of responding to climate change. This is why Rwanda Environment Management Authority (REMA) has prepared sector-specific guidelines to encourage and facilitate the process and adaptation and mitigation.

REMA has been leading the national response to climate change, working with stakeholders to build adaptive capacity at all levels. Indeed, these guidelines are part of on-going efforts to build national resilience and capacity to mitigate and adapt to climate change. The guidelines complement existing tools, and are informed by recent work on climate change and our good practices in environmental mainstreaming, public education and compliance monitoring.

These Guidelines are intended for use by policy makers, planners, technocrats and analysts in the Ministries and Agencies responsible for infrastructure development, embracing the subsectors of energy, transport, water supply, housing and urban development. Other related sectors and non state institutions involved in energy and infrastructure development, are also argued to refer to and use these tools. They are a must-use reference document for formulation, implementation and monitoring of policies, strategies and projects in infrastructure development. While REMA will continue to play its statutory role of coordination, regulation and support, the Ministry of Infrastructure (MININFRA) and Agencies attached to it, must take the lead in mainstreaming climate change adaptation into energy and infrastructure sectors, working closely with other ministries, Local authorities and development partners.

Finally, I would like to recognise the team from the Centre for Resource Analysis (CRA), who assisted us in preparing these guidelines. I applaud the efforts put in by REMA staff especially those associated with the Integrated Management of Critical Ecosystems (IMCE) project which made the production of these guidelines possible. The World Bank is acknowledged for providing the financing. Other national institutions and stakeholders who contributed to developing these guidelines are gratefully acknowledged.

Finally, I argue the relevant institutions and individuals to make use of this and other operational tools developed on climate change to build national resilience against climate change impacts, as it's the only way to assure sustainable development in Rwanda.

Dr. Rose MUKANKOMEJE
Director General, REMA

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Acronyms and Abbreviations

AfDB	Africa Development Bank
CCMA	Climate Change Mitigation and Adaptation
CDM	Clean Development Mechanism
CPAF	Common Performance Assessment Framework
DDPs	District Development Plans
EAC	East African Community
EDPRS	Economic Development and Poverty Reduction Strategy
ENR	Environment and Natural Resources
EU	European Union
GDP	Gross Domestic Product
GHG	Green House Gases
GNESD	Global Network on Energy for Sustainable Development
GoR	Government of Rwanda
GTZ	German Technical Cooperation
IPCC	Intergovernmental Panel on Climate Change
MINAGRI	Ministry of Agriculture and Animal Resources
MINELA	Ministry of Environment and Lands
MININFRA	Ministry of Infrastructures
MINECOFIN	Ministry of Finance and Economic Planning
NAFA	National Forestry Authority
NAPA	National Adaptation Plan of Action
NBI	Nile Basin Initiative
NDBP	National Domestic Biogas Programme
NRM	Natural Resources Management
NUR	National University of Rwanda
OECD	Organization of Economic Cooperation and Development
RECO	Rwanda Electricity Company
REMA	Rwanda Environment Management Authority
RURA	Rwanda Utilities Regulatory Authority
RWASCO	Rwanda Water Supply Company
SIDA	Swedish International Development Cooperation Agency
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on
UNEP	United Nations Environment Programme

1. Introduction

"…Climate change is emerging as the greatest environmental challenge of the twenty-first century. What is more, a virtual Pandora's box of major global threats, such as hunger, poverty, population growth, armed conflict, displacement, air pollution, soil degradation, desertification and deforestation are intricately intertwined with and all contribute to climate change, necessitating a comprehensive approach." FAO.

1.1 General Overview

In 2000, Rwanda elaborated the Vision 2020, a plan expected to transform the country from a low to medium-income country with a healthy and productive population. Half-way to the Vision 2020, tremendous progress has been made in all sectors, and economic growth has doubled from a per capita gross domestic product of US$ 250 to more than US $510 by 2010. Most of the growth that Rwanda has experienced in the last 10 years has come from infrastructure development – housing, energy, roads, water supply, Information and Communication Technologies (ICTs) and lately irrigation. More growth and resource use are expected when the country embarks on the airport, railway and marine projects. The threat of climate change has, however, emerged as a new challenge that could undermine the infrastructure developments and the economic activities that hinge on them, unless efforts are made to develop adaptive capacity. Climate change repercussions will increase the cost of infrastructure establishment and maintenance, result in operational failures, and increase probability of accidents.

Climate change is defined by the United Nations Framework Convention on Climate Change (UNFCCC) as *a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*." More generally, *climate change* is regarded as a change in the statistical properties of the climate system when considered over long periods of time. Accordingly, fluctuations over periods shorter than a few decades, such as El Nino, do not represent climate change.

Green House Gas (GHG) emissions are the main causes of climate change. They arise principally from anthropogenic factors (human activities) although the earth's natural processes contribute too. The types of activities also determine the kinds of GHGs emitted. Thus there is need to: (i) mitigate climate change by undertaking actions that reduce GHG emissions; and (ii) implement measures to adapt socio-economic systems to climate change effects.

Climate change has adverse impact on economies and populations, and poor countries like Rwanda, which are already struggling with inadequate access to modern energy and infrastructure development, are expected to suffer more disproportionately, from the effects of

climate change, notwithstanding their limited contribution to GHG emissions (MINELA, 2010). Moreover, the Inter-Governmental Panel on Climate Change (IPCC) concluded, in its 4th Assessment Report that Africa was likely to experience more warming than the rest of the Planet (IPCC, 2007). This implies that Africa should adapt perhaps more quickly than other regions.

The Government of Rwanda (GoR) has undertaken a number of measures to address climate change, beginning with ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, developing a National Adaptation Action Plan (NAPA) in 2000, and formulating a low carbon growth strategy in 2010. The guidelines are intended to improve the resilience of Rwanda's energy and infrastructure sector to climate change effects and cushion the country's economy from climate change shocks.

1.2 Objectives and Scope of the Guidelines

These guidelines are designed to provide basic and flexible guidance on how to:

i) conduct impact and vulnerability assessments in the energy and infrastructure sectors;
ii) identify opportunities and entry points for integration of climate change mitigation and adaptation (CCMA) measures into the energy and other infrastructure sector processes;
iii) identify, analyse and integrate options for CCMA into the energy and infrastructure policy processes from formulation, financing, implementation and evaluation at national, local and community levels.

1.3 Why Mainstream Climate Change Adaptation into Energy and Infrastructure?

Rwanda's infrastructure sector comprises the sub-sectors of energy; transport; housing and urbanism; water supply and sanitation services; communication and meteorology. As the mandate of MININFRA is infrastructure development, climate change adaptation within the sector will focus on the following:

- reducing the costs of infrastructure development and/ or maintenance by reducing the risk of destruction from floods, heat waves, strong winds, or secondary effects like frequent power breakdowns or road destroyed by landslides;
- increasing the resilience of buildings, highways and water ways to extreme weather events; and reducing the likelihood of accidents and their effects related to infrastructure breakdowns and risks related to system failures or material shortages;
- reducing energy and other utilities in building and other infrastructure operations by adapting construction technologies, materials building standards to weather variability;
- reducing GHGs emissions from inefficient and inappropriate energy sources/technologies;
- reducing or increased prospects for hydropower generation may occur, and

By influencing dialogue on the strategic decisions that need to be made, this document will assist increase climate-sensitive planning and decision making in the energy and infrastructure sectors.

2. Climate Change and Development: Risks, Drivers and Vulnerabilities

2.1 Climate Change: A Global phenomenon with local effects

The term climate denotes the characteristic weather conditions of the atmosphere and its evolution in a specific region. It includes temperature, atmospheric pressure, wind and precipitation. In 1997, the IPCC confirmed that there was unequivocal change in global climate. Since then, average air temperatures have increased, there has been widespread melting of snow and ice, leading to rise in sea level. The 10 warmest years since 1850, are reported to have all occurred within the last 13 years (IPCC, 2007). Deforestation and increasing energy consumption (mostly fossil fuels) are the main causes of GHG emissions and major drivers of climate change, and is expected to increase as global population increases and economic activity increases. This presents a real dilemma for development.

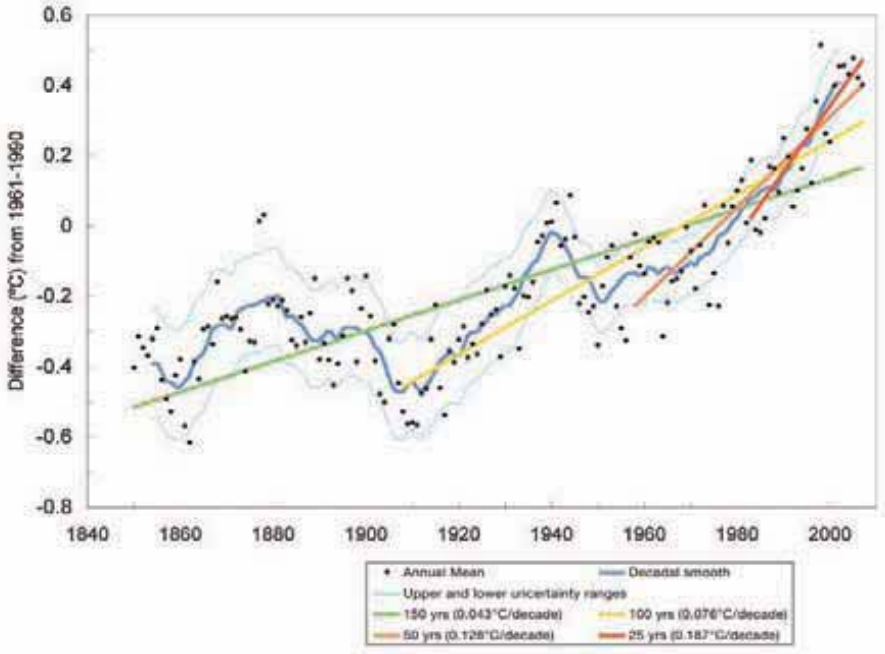


Figure 1: Trends and Indications of Global temperature rise (1850 – 2005)
Source: WHO (2009): Protecting Health from Climate Change.

The most important issues around climate change and development are:

- *It is happening now and will take long to reverse*: In the last 100 years, the World warmed by approximately 0.75°C (figure 1), with a much higher rate in the last 25 years (0.18°C every 10 years). The IPCC predicts that if current trends in GHG emissions are not altered, global temperatures are expected to rise between 1.4 and 5.8º C by 2100.
- *Extreme weather events are changing in frequency and intensity*: It is considered that heat waves have become more frequent over most lands, and the frequency of heavy and erratic precipitation events has increased over most areas, including Rwanda.
- *Human activities are the main cause of climate change*: Most of the observed increase in temperatures since the mid-20th century is attributed to unprecedented increase in human activities especially in economic and social development.

- *Human-induced climate change will continue for at least the next few decades, making the need to adapt, important and urgent:* The development options chosen will influence the rise in temperatures, but, as figure 2 indicates, even if GHG emissions were to halt immediately, temperatures would still rise by over 0.6°C in this century (IPCC, 2007). A scenario where sustainable energy use is prioritized, temperatures are expected to rise by 1.8°C (range 1.1–2.9°C). A lower sustainability scenario, on the other hand, will lead to a temperature rise of 4.0°C (range 2.4–6.4°C), with a greater probability of abrupt or irreversible problems.

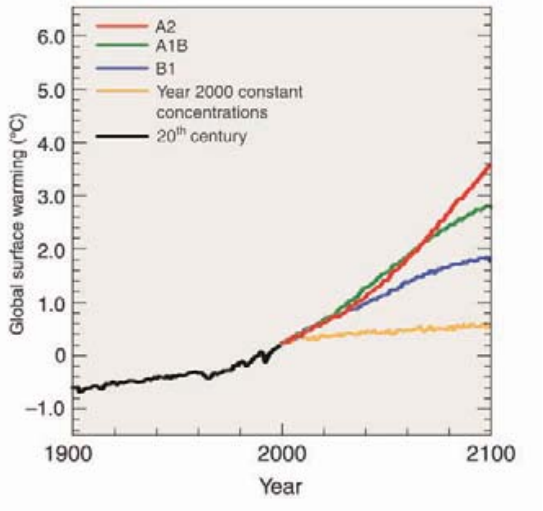


Figure 2: Projected global temperature rise in the 21st Century[1]. Source: IPCC, 2007 (In WHO, 2009).

As indicated in figure 2, either scenario will result in net temperature increase. Hence, reducing GHG emissions will not reverse climate change in the immediate term. Adapation to changing climate will be critical to human survival and development sustainability.

2.2 Climate Change Impact and Vulnerability of Energy and Infrastructure Sectors

Climate change and development are closely interwoven. Climate is a resource in itself, and it affects the productivity of critical resources on which energy and infrastructure development are based (e.g. water for hydropower development and transportation; increased cost of constructing roads in frequently flooded areas or those under the threat of landslides). Potential impacts of climate change on energy use and infrastructure development exhibit spatial and temporal variations, and include:

- **Transportation:** Climate change may cause more flooding of roads, bridges and airport runways, especially in low land areas as a result of erratic rains and stiff rising sea levels and surges brought on by more intense storms. Transport accounts for about a quarter of global energy-related GHG emissions (International Energy Agency (2009)), of which 65 % originates from road transport and 23 % from rail, domestic aviation and waterways (Chapman (2007)). Transport energy use and CO_2 emissions are projected to increase by nearly 50 % by 2030 and more than 80 % by 2050.
- **Energy production will be affected differently, but mostly could decline:** climate change effects on forest resources could result in more trees and woodlands are converted into agricultural lands, with the likely negative impact on biomass energy availability and access. On the other hand, climate change provides opportunity to increase forest cover

[1] Projected temperature changes (relative to 1980-1999) in selected development scenarios, from lower emphasis on sustainable development and cooperation (A2) to greater attention to environmental protection and regional integration (B1). The orange line is the projection assuming GHG concentrations held constant at year 2000 values.

and reduce consumption of fuel wood and other biomass resources. This could also negatively affect access to biomass energy considering that the alternatives to wood are still likely to be fewer and more costly for a sizeable proportion of the population.

- **Hydro-power production** (the cleaner more renewable source of energy) will be positively and negatively affected, depending on the effects and how the effects are managed. Intensive rains will increase water flow in the river systems, enabling the country to increase electricity generation capacity. On the other hand, persistent drought will reduce water levels in major lakes and rivers and swamps and lead to lower power production. Rwanda has already experienced this crisis especially around 2003-2004.
- **Climate change will affect settlement patterns and housing**, through internal migration (already happening with the influx of people from Western and Northern provinces to Eastern province): increased hazard risks especially in hilly areas could facilitate the implementation of grouped settlements
- **Energy consumption in households and commercial buildings is likely to increase**. Rwanda is likely to experience hotter than normal days, necessitating increased cooling efforts.
- **Safety and resilience of infrastructure**: buildings, telecommunication infrastructure, grouped settlements, etc., could be destroyed by floods or strong winds and extreme temperatures, unless provisions are made to reinforce the structures. The high rise building advocated in the urbanization policy will require extra safety provisions;
- **Climate change effects will also be influenced by the development policies and models adopted.** Climate adaptation may be compromised when people are compelled to settle in fragile areas (e.g. steep slopes or wetlands); build houses that are not climate resilient (e.g. use of raw bricks instead of baked bricks due to rising cost); and become susceptible to poverty and health hazards due to breakdown in communication and increased epidemic risks as a result of flooding or road breakdown.
- **Water supply and sanitation systems could be affected by water stress and reduced water levels.** Water supply installations could be destroyed and their functionality undermined in flood susceptible areas or landslide-prone regions.

This makes it absolutely essential to adapt to climate change in order to minimise its effects on people and economies.

3. Vulnerability and Response to Climate Change in Rwanda

"Africa will probably have the greater and more severe impacts from climate change than other parts of the World. And yet this is very marginally, if at all, a problem of Africa's making," President Paul Kagame, Address to UN General Assembly, New York (September 22, 2009).

3.1 Overview of Climate Change in Rwanda

3.1.1 General

Recent events and meteorological data provide glaring evidence that climate change is happening in Rwanda and that it will have disastrous effects. The 1997 floods and prolonged drought of 2000 associated with El Nino and La Nina (MINITERE, 2006) are some of the extreme climate change events that Rwanda has suffered recently. Over the next century, annual temperatures in Rwanda are projected to be 1.0 °C to 2.0° C higher (MINELA, 2010). Analysis of the mean annual temperatures of Kigali Airport Station (1971-2007) in Kigali city and Kamembe in the Western Province (figure 3) reveals consistent temperature increase. For Kigali, the average temperature rise of 1.2°C from 19.8°C in 1971 to 21.0°C in 2009 is worrisome. It exceeds 0.8°C reported to have been caused by global warming over a period of 150 years.

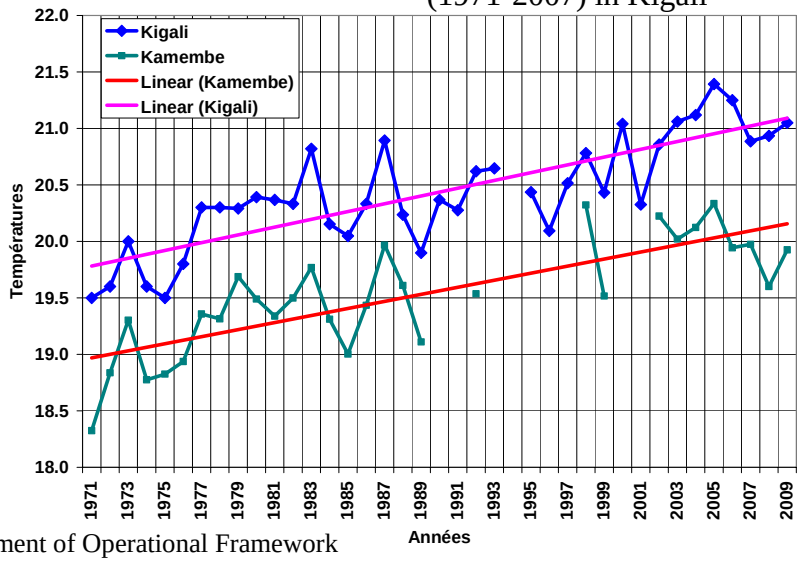


Figure 3: Mean Annual Temperature Variability in ° C (1971-2007) at Kigali and Kamembe Stations.

Data Source: Mutabazi (2010). Assessment of Operational Framework related to Climate Change.

3.1.2.GHG Emissions and underlying Causes of Climate Change in Rwanda

A recent GHG emissions study concluded that the main GHGs in Rwanda were Co_2 (comprising 87% of all GHGs); Methane (CH4) accounting for 11.5% and nitrogene hemioxide (N_2O) which accounted for 2% of GHGs. The main sources of GHGs are: Agriculture (which contributed

78%), Energy (17.8%), industrial processes (3%), wastes (0.9%) and land use change and forestry (0.2%). The recent records indicate that Rwanda's total GHG emissions were 5,010.4Gg carbon equivalents and total absorption was -8545Ggr. With a net national balance of -3534.6Ggr, Rwanda is a net sink. The main concern, however is that while absorption increased by half (53%), the emissions from biomass increased by 100% (from 2896.34 to 5793.45Gg). Furthermore, emissions from agriculture increased by nearly 1.5 times. This is a challenge given that agriculture is the main source of livelihoods and contributor to growth. The low increase in energy-related GHG emissions (under 10%) despite increased energy consumption suggests that investments in cleaner energy alternatives are paying off. Despite relatively low GHG emission levels, Rwanda is vulnerable to climate change. The following sections indicate how the different energy and infrastructure sub-sectors are vulnerable.

3.2 Vulnerability and Response in the Energy Sub-sector

3.2.1 Vulnerability in the Energy Sub-sector

Climate change is expected to have noticeable effects on energy and infrastructure. Rising temperatures are already being experienced in Rwanda as indicated in figure 3, as are changes in rainfall amounts, seasonal patterns and intensity in all climatic zones of Rwanda. Many of these effects have clear implications for energy production and use. For instance, increased warming is expected to increase energy demand for cooling (Air conditioning) and yet reduce prospects for energy production (if heat is related to prolonged drought and less rain). Changes in precipitation will affect hydropower, positively or negatively. Increases in storms and landslides will affect infrastructure in most parts of the country. The energy sector in Rwanda is particularly highly vulnerable to climate change effects for a number of reasons:

- all energy sources are directly or indirectly linked to climate parameters i.e. temperature, precipitation, wind;
- the energy sub-sector is highly inefficient (about 22% of primary energy is lost in diesel power generation, electricity transmission and distribution losses, and charcoal making);
- low levels of technology use in production and distribution (traditional kilns used in charcoal production);
- low levels of production implies most energy users will not be able to pay significantly higher costs of energy, as anticipated under climate change scenarios. Most energy users are households (91%) and only less than 5% are businesses and industries.

✓ **Biomass energy** (fuelwood, other vegetation materials,..) account for at least 95% of domestic energy demand, and is expected to remain the main source of energy over the next several decades.

Table2:

Energy source	Potential Effect of/on Climate Change	Occurrence Likelihood			Adaptation Reponses
		H	M	L	
Biomass	• Increased incidences of drought will imply reduced biomass productivity and a decline in fuel wood supply; • Change of habitats will affect production and	x	x	x	✓ mproved cooking stoves and other efficiency measures; ✓ Biomass alternatives e.g. biogas – good option to accompany and

	regeneration potentials of individual species; • Temperatures will affect the production of tree seeds/fruits and reduce planting , • Intensified & inefficient use increases GHG emissions				accelerate the One cow per poor household programme. ✓ Behaviour change – reduce the amount of heating to essential ones; timing and planning are critical. ✓ Fast growing species for biomass energy e.g. eucalyptus; ✓ Multipurpose tree/shrub species appropriate for small land holdings
Hydro-power	• Reduced precipitation will reduce water flow and slow down power production. However, increased precipitation will result in higher hydropower generation potential. However, the runoff water has to be harnessed. • Flooding & landslides damage or destroy HEP infrastructure (dams, transmission & distribution networks) and may create conflict with downstream communities or increase social vulnerability e.g. thru involuntary resettlement. • Energy security and economic development activities will be compromised and production costs will increase.				✓ Promote ecologically compatible livelihood activities within the watershed where power is generated; ✓ Improve operation and maintenance (O&M) at all power stations through training, guides, technological transfer & regular inspections; ✓ Engage policy makers and facilitate integration of Climate Change consideration into the hydroelectric sub-sector management. ✓ Introduce safeguards for long-term sustainability of hydropower use in Rwanda: generate information about Climate Change to help integrate this knowledge into energy and sustainable development policies. Incorporate Climate Change considerations into annual performance contracts of districts using a pilot approach.
Petroleum products	✓ Consumption has increased as a result of increased automobile numbers and heavy industrial machinery that are powered by diesel. ✓ If incidences of prolonged drought increase, importation of petroleum products (especially heavy diesel for generators) will increase, triggering a cycle of GHG emissions and climate change effects. ✓ Economy's ability to cope with climate change shocks will decline as foreign exchange outflows increase to import petroleum. More than 40% of the country's foreign exchange is spent on petroleum imports.				
Methane gas	✓ However, a possible decline in the water levels of Lake Kivu may affect the methane exploration and production process. ✓ Methane will assist provide cheaper and more environmentally friendly energy source.				✓ Exploitation of large deposits of methane gas (CH4) in Lake Kivu is an opportunity to reduce GHG emissions; ✓

Bio-diesel	✓ Reduced precipitation/moisture will result in lower productivity ✓ Changes in temperature will affect yields. ✓ Drought and shrinking land for production will increase competition with food crop and livestock production for land use.	X			
Peat	Land use change (wetlands into agriculture/horticulture) will alter and disturb peat land hydrology, resulting in peat oxidation and; loss of peat potential. Peat disturbance will increase GHG emissions especially CH4. Increased use of peat as alternative will release stored Co2 into atmosphere, hence GHG emission increases.	X			In the post production phase, the reclaim cutaway peat-lands into forestry or reconvert to Wetland status to restore it as a carbon sink.

Rwanda has already faced the effects of climate change and the energy sector has some successful experiences in dealing with such effects, as a summary message in box 1 indicates.

Box 1: Climate Change Adaptation in Electricity sub-sector: National response in a regional framework

During 2004-2005, Rwanda experienced prolonged droughts, a typical climate change effect, which significantly reduced the water levels in Rivers and Lakes. This affected power generation forcing states in the Lake Victoria Basin to increase thermal electricity generation, with its accompanying negative environment effects and high cost per unit, to meet the electricity needs. Hydropower generation, the dominant modern energy source in the country, is likely to be the most directly affected by Climate Change because; it is sensitive to the amount, timing and geographical pattern of precipitation and temperature. As the turbines at Ntaruka and Mukungwa could not turn due to low water levels in upstream lakes and swamps (all the way to Rugezi), the entire country plunged into darkness. The Government of Rwanda (GoR) resorted to high cost, high polluting diesel generators. It was costly because, in fuel alone, some US$65,000 was being spent daily. Soon the nation sobered up and went back to restore nature – taking on long-term adaptation measures that have helped restore ecosystems to recharge water sources and fix other climate change effects. As these initial interventions worked, the GoR was thrilled and decided to implement some pilot projects one of which was under a regional programme- "*Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Eastern and Southern Africa*" *(ACLIMATE CHANGEESA).* This was designed to build the resilience of Rwanda's (and Africa's) hydroelectric sub-sector by achieving 3 objectives, viz:

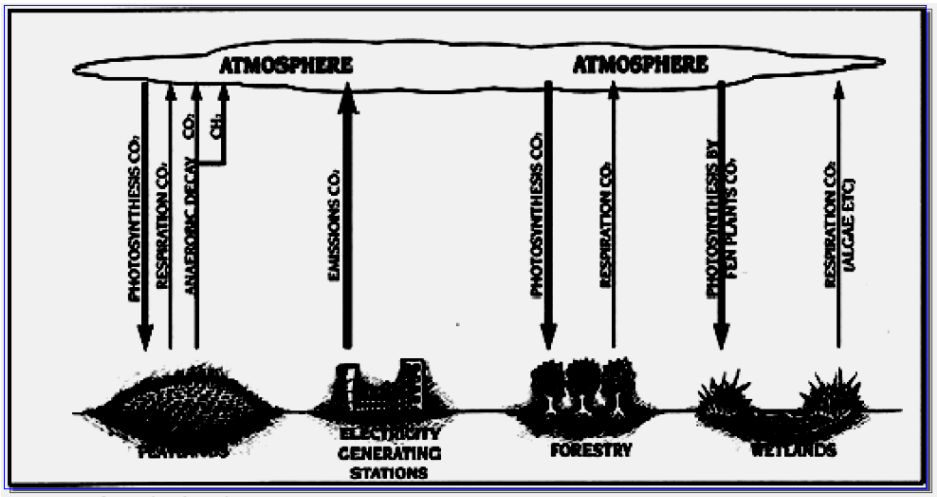
- Restore and protect the watershed supporting the Ntaruka and Mukungwa power plants while working to improve community livelihoods within the watersheds. This reduces both social and ecological vulnerabilities linked to climate change effects;
- Integrate climate change considerations in the management and operation of the hydroelectric production;
- Promote the integration of vulnerability and adaptation to Climate Change into energy and sustainable development plans and processes in Rwanda.

In the meantime, the aftermath of the climate change-induced power crisis has influenced MINIFRA to shift towards renewable energy in order to meet the country's anticipated huge power needs for industrialisation and social transformation.

3.2.2 Vulnerability of Peat production as an Alternative Energy Resource

Rwanda has considered peat as an alternative energy source. There are considerable reserves of peat across the country. Peat has been used for domestic energy purposes by local communities in many parts of the World for centuries. Electricity generation, using peat as a fuel, developed in the 20th Century in Europe. Peat consists of organic materials derived almost completely from the accumulated remains of vegetation currently or formerly growing at the site of occurrence. It is found in all stages of decomposition, and can be classified in different ways according to its usefulness for a wide variety of purposes, which can be for horticulture, energy or industry. (http://www.rwandainvest.com.cn/DetailA2.asp?ID=188&intMaxID=)

Figure 4: An illustrative model for clean and sustainable production of peat energy



Source: Bord na Móna (2001)
Figure 7: An Example of a Sustainable and clean method of Using Peat for Energy

How is peat energy production vulnerable to climate change?

Agriculture, forestry and peat extraction for fuel and horticultural use are the major causes of peatland disturbance. When peat-lands are drained and developed, they stop absorbing carbon dioxide. Of particular interest is the fact that the methane emissions, which are a worse gas than CO_2 in causing Climate Change, also cease when peat is extracted. This contrasts with non-renewable sources of energy, such as coal, oil and natural gas, which are extracted from deep underground and which cannot generally be restored to active carbon sinks (Bord na Móna 2001). Thus, with proper post-extraction management, peat is a clean fuel.

3.3 Vulnerability and Response in the Transport Sub-sector

3.3.1 Climate Change Concerns in Rwanda's Transport Sub-sector

Transport takes the biggest proportion of the infrastructure budget, amounting to 49% in 2008. It is estimated to contribute more than 40% of the total value of international trade as compared to 6.5 and 11% for imports and exports respectively in developed countries. This cost could increase as a result of climate change. Its realised importance as a fulcrum for socioeconomic transformation in Rwanda is evident in the recent establishment of the Rwanda Transport Development Agency (RTDA).

At least 3 climate changes will have direct effect on Rwanda's transportation system, viz:

- increases in intense precipitation events;

- increases in very hot days and associated heat waves; and
- Increase in strong winds and hailstones.

How vulnerable is Rwanda's transport sub-sector?

In Rwanda, transport represents the fastest growth source of emissions, and is a key issue because of growing urbanisation. The increase in petroleum product imports has serious implications for GHG emissions in addition to the high import and transport costs to Rwanda due to its distance from a port and the delays of bringing the fuel across borders. Low carbon options would therefore have both environmental and economic benefits. Source:Rwanda Second Communication under the UNFCCC

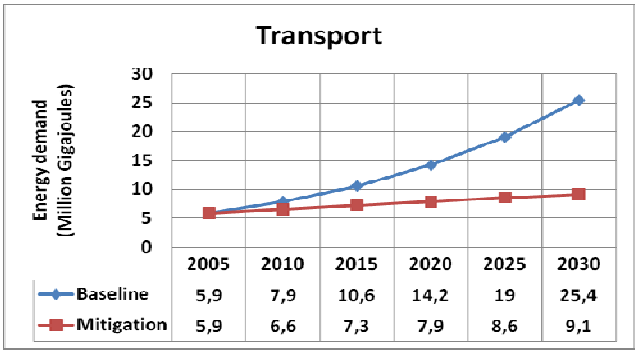


Figure 8: Total Energy Demand for Transportation

Examples of specific types of impacts of climate change to transport include softening of asphalt roads and damage to roads and flooding of roadways and airports from extreme events and interruptions to flight plans due to severe weather. The long-term development of Rwanda, as it is elaborated in the vision 2020 assigns fundamental importance to the development of the economic infrastructure of the country, and in particular transportation infrastructure. Indeed, the poor state of international roads that form part of the transit corridor, together with other physical and non physical barriers increases the costs of imported and exported commercial products, while the poor state of the road network in the rural areas constitutes an obstacle to improvement of productivity, the development of internal trade, whereas the access to markets constitute a priority for the Vision 2020.

- While asphalt roads are categorized as all weather and therefore deemed more resilient to extreme weather events, only one-fifth (20% of the country's road network is paved with asphalt. The rest is earth which is highly vulnerable to destruction by heavy precipitation, drainage blockages.
- Asphalt roads are also constructed on the basis of standards adopted from elsewhere. Specific local conditions require national infrastructure such as laboratories.

Response in the Transport sub-sector

: Among the major challenges for the transport sector is the ownership of cars which is growing at impressive rates in developing countries. In many Sub-Saharan countries, the importation of used vehicles, which are more likely to experience reduced efficiencies, is a booming business.

Table 3: Climate change Adaptation Actions in the Transport Sub-sector

	Policy Response	**Specific Actions**	
	Controlling vehicle use	• Outlaw the importation of old vehicles (use EAC partners as benchmarks); •	
	Optimising the transport modes in the country	• Encouraging public/bulk transportation systems (Buses, Rail) by reducing costs for public/bulk transportation and giving priority to public transport in urban areas and developing pipelines for gas and liquid fuels, • Controlling the growth of personal vehicles by instituting car charges/taxes to be used in	

		mitigation activities	
	Set emission standards to strengthen	• The adoption of fuel efficient technologies, • The promotion of high efficiency and cleaner vehicle market penetration, • Regular vehicle inspection	
	Set and enforce standards for fuel quality	-Put in place fuel specification standards	
	Promote environmentally clean alternative fuels like	• The production of bio-fuels, • The use of natural gas as an alternative vehicle fuel which reduces carbon dioxide emissions;	

The major question governments are facing is how to include long term climate change in the transport systems strategy and planning , but short term measures will include:

Road infrastructure:

The other problem with regards to transportation is the poor road network. The condition of the whole road network has deteriorated substantially in the past decade, resulting in a significant cost to the economy. As far as can be ascertained, the condition of bridges, viaducts, and culverts mirrors that of the roads of which they form a part.

According to the GTZ (2009) report on the economic impact of climate change in the East African Community, the East African transport system was designed and built for local weather and climate conditions, predicated on historical temperature and precipitation data. The climate change projections on which all national impact and vulnerability assessments are based rely on a limited number of older generation of climate models and scenarios. This may imply that the current climate predictions by planners and engineers may no longer be reliable in the face of the new weather and climate extremes. Due to climate changes experienced in the recent past, the road infrastructure is more vulnerable to flooding and landslides rather than temperature changes. Detailed modelling of the frequency and intensity of rainfall impacts on infrastructure in the local and regional context is still a major challenge.

The operating costs of vehicles in Rwanda are high, as a direct consequence of the poor condition of the roads, and access to both product markets and essential public services is impaired, especially in poor rural areas. A major cause of the poor state of the roads is the heavy runoff as a result of climate change and variability. Failure to address environmental issues such as runoff on steep slopes will only increase the cost of infrastructure maintenance, with disastrous consequences for poverty reduction.

Adaptation Assessment

Adaptation enhances resilience or reduces vulnerability to observed or projected changes in climate (PPIC, 2008). Reducing vulnerability may address one or many of the projected impacts of climate change. For example, elevating roads close to water bodies reduces vulnerability to the impacts of anticipated water level rise or reduces vulnerability to storm surges. Alternatively, adaptation may increase a system's resilience to future impacts through the fortification of structures or implementing measures to increase a system's ability to bounce back after an impact.

General Methodologies

a) **Identify Adaptation Responses**. There are three types of adaptation responses relevant to transportation planning which address climate impacts at varying time scales: protect, retreat and accommodate. These responses can be put into practice through investing in infrastructure and technology or changes in management approaches (PPIC, 2008; CCSP, 2008):

- Protect includes such options as redesigning the infrastructure or instituting measures to reduce the climate impact (such as armouring against storm surges).
- Retreat includes abandonment of the infrastructure.
- Accommodate includes operational strategies that can be implemented to reduce the climate impact (such as pumping water after a flood event).

b) **Determine Appropriate Adaptation Action.** Adaptation actions may be either incorporated into existing policies, practices and procedures through some modification or, in some cases, new policies, practices, and procedures will need to be created (Snover et al., 2007). According to the Climate Impacts Group (CIG) at the University of Washington (2007), modification to existing policies, practices and procedures should: allow regular re-evaluation and adjustment in accordance with changing conditions; require planning that is not based strictly on the past, and does not restrict certain decisions to certain periods or seasonal patterns; and reinforce trends that reduce vulnerability or increase adaptive capacity. On the other hand, climate change adaptation can be incorporated into existing planning through modifying zoning codes, land use planning guidance, or emergency planning.

c) **Select and Prioritize Actions**. Adaptation assessments may identify a wide variety of potential options for considered action. In order to prioritize and select among these options, planners may consider a range of criteria including: the timeframe of risk; design life of the infrastructure at risk; cost of action/inaction; the likelihood of the action n to reduce risk; the timeframe for implementation; and other constraints or limitations (Snover et al., 2007) (see Box 7 for more discussion).

d) **Implementing Actions.** Once particular actions have been identified, a plan for implementation is developed. Implementation may include near-term operational and maintenance responses or longer-term design strategies (see Box 6). Implementation is often the most difficult stage of adaptation to accomplish. Plans may languish on the shelf unless the actions identified in the plan are tied to specific actors and timelines for implementation. In many cases, implementation will require input and cooperation from several actors inside and outside the relevant transportation agency.

e) **Measuring Progress**. Standards for evaluating effectiveness may need to be developed and re-evaluated in order to facilitate the periodic evaluation process. The timeframe for measuring progress in climate change preparedness will depend on: the nature of the vulnerabilities and risks that are addressed in priority planning areas; the planning horizon, investment rules and/or other factors related to a given capital project or system in a priority planning area; and organizational planning and budget cycles (Snover et al., 2007). Over time, climate change data and information used to develop planning goals may need to be updated based on new research. Climate change

plans and actions will also need to be regularly updated once new information has been reviewed and basic assumptions have been examined (Snover et al., 2007).

3.4 Vulnerability and Response in the Housing and Urbanism Sub-sector

3.4.1 How Vulnerable is the Housing and Urbanism Sub-sector to Climate Change?

Households are vulnerable to floods, the extreme temperatures as well as the increased number of mosquitoes that cause malaria. In some cases some households have use more firewood to warm themselves during cold nights.

Habitat and Urbanism contributes sensitively to the economic growth of the country by developing services, employment, industries, etc…. In 2004 and 2005, the contribution of the sub-sector to the GDP was approximately 10.5%. For the construction only, it generates substantial incomes to the households and contributes appreciably to the poverty reduction, because 30% of its costs are ascribable to the labour.

Domestic energy use is a major contributor to CO_2 emissions. Improving energy efficiency and increasing the use of carbon neutral energy sources in both new and existing homes is the sector's greatest challenge. MININFRA which is responsible for the creation of sustainable habitats and urban centres must rise to this challenge adaptation to climate change (http://www.ica.coop/al-housing/categories/).

Adaptation and Mitigation Actions in the Housing and Urbanism Sub-sector

Table 5: Adaptation Actions in the Housing and Urbanism sub-sector

	Climate parameter	Action	Overall effect
	Temperature & household energy use	• Adjusting air conditioners to room temperature (20–25°C range) to save and reduce energy costs for AC Locate air conditioning and heating systems properly to avoid inefficient use, such as the infiltration of hot air into cooled space and vice versa. • Regular cleaning of filters and coils in air-conditioning units can have an energy-saving effect. • Introduce systems to shut down air conditioning automatically when balcony doors or windows are opened. • Review building design, including positioning, material and insulation can provide an important precondition for maintaining acceptable temperatures.	reduce energy use
	Energy Conservation for the Building Materials	• Set and enforce standards for low carbon building materials • Promote renewable energy technologies for cooking and lighting in the imidugudu • Introduce a Code for Sustainable Homes for measuring and improving the environmental performance of all buildings. Set and enforce standards for buildings to take care of climate change and variability challenges.	

	Floods	• Develop a standard for a balanced mix of housing type and density levels guided by a spatial strategy or spatial master plans • Establish local design review panels where developers and design teams can engage positively with local planning authorities • Facilitate Architects in research to support housing providers in finding new solutions of general application • Setting and enforcing standards for buildings to take care of climate change and variability challenges.	
	Household Energy Use	• In the tropics temperatures in rooms are comfortable at levels between 20–25°C (UNWTO-UNEP-WMO 2008). However, air conditioning is often adjusted to lower room temperatures than 20°C, even though substantially higher values are comfortable. • Technical options to further reduce energy use include thermostats, combined with systems to heat or cool rooms only shortly before they are used. It is crucial to • Promote renewable energy technologies for cooking and lighting in the imidugudu • The standards for the Architectural designs of houses should be mosquito proof allow for natural indoor temperature regulation • Set Standards for air conditioners in urban areas	

3.4.2 Entry points for CCMA for the Habitat and Urbanism sector

Rwandan cities and towns are projected to hold more than 50% of the population in the Vision 2020. It is imperative, therefore to protect the urban population and economy from climate change effects.

During the EDPRS period, 11 master plans will be produced, 5.700 ***imidugudu*** sites will be created and 10.000 ha will be developed in urban areas and basic equipment will be provided. The public offices will meet the conformity standards to reach high quality services and public security in the aim to achieve the objectives of the EDPRS.

The policy of urbanization put a particular emphasize on the planning and the viability of the land plot sites to allow a sustainable urbanization. The institutional and financial capacity building of the local community agencies enables them to fulfil their duties of planning and urban settlement.

3.5 Vulnerability and Response in Water Supply and Sanitation Services

3.5.1 Impact and Vulnerability in Water Supply and Sanitation Services Sub-sector

Impacts of Climate Change on the WSS Sector

Global warming will impact water temperatures, which are expected to have substantial effects on energy flow and on the recycling of matter. This in turn may result in algal bloom, an increase in toxic cyanobacteria bloom and diminished biodiversity. The composition and quality of water in rivers and

lakes is likely to be affected owing to changing precipitation and temperature resulting from climate change. At the same time, changes in precipitation intensity and frequency influence non-point source pollution, making the management of wastewater and water pollution more demanding and urgent.

Climate change will directly affect the demand for water; for instance, changes in demands will derive from industrial and household use, or from irrigation. Water demand for irrigation may increase as transpiration increases owing to higher temperatures. Depending on future trends in water use efficiency and the development of new power plants, the demand for water in thermal energy generation could either increase or decrease. In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) has concluded that there is a 90 per cent probability that the extent of drought-affected areas will increase

The government's core policy objectives for the water supply and sanitation sector are to improve the provision of water, extend the water supply network, and increase access to sanitation services, using means that promote technically and financially viable projects based on strong community participation, as well as to strengthen capacity at both the central government and the district levels. Government has committed itself to reaching very ambitious targets in water supply and sanitation, with the vision to attain 100% service coverage by 2020. 32% of Rwandans use piped water, but only 3.4 % have access to it within their house or plot (urban: 17%, rural: 0.9%). On average, households – women and children – spend 29 minutes per day on fetching water in rural areas (9 minutes in urban areas)7. Daily per capita consumption is of the order of 6 to 8 litres per day in rural areas, a figure by far lower than the envisaged standard consumption of 20 litres.

Water resources occupy 8% of the total area of Rwanda but due to lack of data, it is difficult to estimate the extent which climate change has impacted on water resources (REMA 2010). Only 52% of Rwandans have access to clean water of which, 32% use piped water, but only 3.4 % have access to it within their house or plot (urban: 17%, rural: 0.9%). On average, households – women and children – spend 29 minutes per day on fetching water in rural areas (9 minutes in urban areas). Daily consumption of water is estimated at 8.15 litres per person in rural areas, far below the international standard of 20 litres. The country is endowed with reserves that could provide enough water for both consumption and agricultural purposes. These include substantial rainfall (between 900 & 1800 mm per year) and the abundance of lakes, streams and watercourses. Furthermore, there is an abundant supply of high altitude water in the western part of the country, which may be used in providing water by gravity to the southern and south-eastern regions of the country that face water shortages. In order to achieve the goals for water set out in Vision 2020, the country will have to increase the rate of potable water by 2.5 percentage points, annually from the current rate of 52% so that the whole of the Rwandan population will have drinkable water by 2020.

a ***Water Supply:*** Raise rural water supply coverage to 85% by 2012 and to 100% by 2020 by assisting the Districts to plan, design, finance and implement infrastructure projects

b Ensure sustainable functionality of rural water supply infrastructure by developing effective management structures and well-regulated public-private partnership (PPP) arrangements.

c Ensure safe, reliable and affordable urban water supply services for all (100% service coverage by 2012) while strengthening the financial viability of the Utility.

1 ***Sanitation***

a. Raise household sanitation coverage to 65% by 2012 and 100% by 2020, and promote hygiene behaviour change.

b. Implement improved sanitation for schools, health facilities and other public institutions and locations.

c. Develop safe, well-regulated and affordable off-site sanitation services (sewerage and sludge collection, treatment and reuse/disposal) for densely populated areas.

d. Enhance storm water management to mitigate impacts on properties, infrastructure, human health and the environment

2 ***Solid waste Management***

e. Implement integrated solid waste management in ways that are protective to human health and the environment.

The sustainable operation and management of rural water supply infrastructure is one of the key challenges of this sub-sector. Approximately one third of the existing infrastructure (about 850 rural water systems) needs rehabilitation. However, the situation has changed significantly with the delegation of service responsibility to the districts and the introduction of delegated management. Rwanda's WSS services sector is generally dynamic and coverage rates are increasing (from a relatively high level at African scale) through successful large implementation programmes. The percentage of schemes managed by private operators is rising fast (attaining about 28% in 2008) and the first evaluations, in terms of improved functionality, are encouraging. Urban water supply services in 14 towns, including the City of Kigali, are provided by a public utility operating on a commercial basis. Service coverage within the contiguous built-up urban area is generally reasonable while peri-urban areas are not always well served. In Kigali major investments have managed to secure adequate supplies from a variety of sources (surface water, springs, and groundwater / bank filtration).
The sustainability of infrastructure management is improving since decentralisation and the introduction of public-private partnership, with independent regulation being assured by a regulatory agency

3.5.3 Climate Change Adaptation in the WSS Services

Water resources have always varied in time and space. From a technological and engineering standpoint, water managers have routinely dealt with the uncertainties and vagaries of historical climate variability fairly well. The core business of water resources management in most cases has been coping with variability: storing excess water from wet periods to bridge dry spells, protecting low lying areas from floods, balancing withdrawal between upstream and downstream areas and between different uses etc. From the point of view of water management, Climate Change therefore does not entail something radically new. However, water managers have frequently had much greater difficulties with the institutional and policy aspects of water management, particularly in developing countries. It means that as the dynamic characteristics of the hydrological cycle change and is no longer stationary over the life span of current and planned hydraulic infrastructure the institutional and policy aspects should be flexible to cope with the new challenges. A changing climate is directly felt in the water sector; consequently, much work on adaptation and building resilience needs to be done through the water sector. (UNDP, Water Governance; 2nd March 2011; http://www.undp.org/water/crosscutting/climate.html).

4. Opportunities and Entry Points for Mainstreaming Climate Change Adaptation in Energy and Infrastructure development

4.1 Introduction

Mainstreaming climate change adaptation describes a process of considering climate risks to development projects, and of adjusting project activities and approaches to address these risks. The assumption is that the project has a goal related to poverty reduction, livelihood security, or improved well-being for target populations and that the sustainability and impact of the initiative can be increased by integrating climate change. This is different from a "targeted" community-based adaptation project, where the explicit goal is to build resilience to climate change. Mainstreaming climate change adaptation can therefore ensure that development programs and policies are not at odds with climate risks both now and in the future.

Mainstreaming climate change adaptation can achieve two main objectives:

- reducing the risks posed by climate change to project activities, stakeholders, and results, sometimes referred to as 'climate-proofing'
- ensuring that project or program activities maximize their contribution to adaptive capacity of target populations - and do not inadvertently increase vulnerability to climate change - through interventions designed to build resilience while achieving development goals

'Climate-proofing' is primarily concerned with protecting development investments and outcomes from the impacts of climate change. It increases the sustainability of projects by analysing the risks posed by climate change to project activities, stakeholders, and results, then modifying and/or adjusting project designs or implementation plans to mitigate those risks. For example, an increase in the frequency and severity of floods may require water pumps to be built above predicted flood heights in order to ensure the availability of safe water over the longer-term (Huxtable and Thi Yen, 2009).

4.2 Overview of the Energy and Infrastructure Policy Processes

The transport infrastructure in Rwanda comprises of the following:

i. Road transport, which until now is the main form of passenger and goods transportation, with a network of about 14,000 km corresponding to a road density of 0.53 km/km^2,

ii. Air transport with, two international airports and six aerodromes spread across the country, and

iii. Lake transport, which is limited mainly to the Lake Kivu. Rwanda does not have a Rail transportation system but the rail road systems of the neighbouring countries (Tanzania, Uganda and Kenya) which are used as transit routes contribute in a small way for goods originating or destined for Rwanda, in a multi-modal railway-road combination.

Road transport is highly sensitive to climate variations given that the proportion of motorable road network was about 11% by 2005 and is expected to reach 31% by 2012 (EDPRS 2007-2012).

The overall policy objective of the transport sub-sector is to reduce constraints to transport in order to promote sustainable economic growth and contribute to poverty reduction.

Table 6: Mainstreaming CCMA within the transport sub-sector outcomes/ objectives

Strategic Objective	Climate change issues	Adaptation Actions	Required tool(s)
1. Strengthen the institutional framework and capacity of transport institutions and stakeholders, in planning and management of the sub-sector.			
2. To reduce and control Transport costs.			
3. Assure quality and sustainability of the rural, urban and international transport networks.			
4. Improve safety for goods and passengers on the principle modes of transport.			
5. Establish a system to ensure sustainable financing of road maintenance.			
6. Facilitate access to cost effective transport services.			

Opportunities for mainstreaming

The process of mainstreaming/integration of Climate Change must be premised in the national development vision. In order to develop guidelines for mainstreaming Climate Change, a number of issues must be established. These include;

- **i.** Establishing the extent of vulnerability,
- **ii.** Assessing the capacity for adaptation including research and data collection,
- **iii.** Establishing the trends in specific sectors in terms of production,
- **iv.** Establishing how policies are formulated and decisions made,

Given that policy processes are highly context-specific (socio-economic and geo-climatic), it is essential to understand the particular context and the characteristics of the policy, to grasp the specificity of the policy-making process in order to effectively play a role in shaping it. Some of the lessons leant from studies that analyse policies in different countries include the following:

a. Policy statements should go beyond ‘statements of intent’ to provide a roadmap for specific measures and an implementation plan.

b. Policy is strengthened by underpinning studies/research. Since policy many times is intended to influence behaviour of communities, assumptions in policy formulation may not be avoided. The effectiveness and usefulness of a policy therefore, will depend on the accuracy of the assumptions

made. The accuracy of the assumptions will depend on the nature and quality of research/studies conducted Bressers and Klok (1988).

c. Consultations help to obtain ideas and include various stakeholder viewpoints; promote coordination and collaboration, and enhance transparency and trust in the process.

d. The inclusion of civil society helps build support for policies and thus aids in implementation. Consulting and partnering with the private sector can help increase the feasibility and market-friendliness of policies that are proposed. This can facilitate greater private sector engagement in achieving low carbon growth and improve the sustainability and scale-up of green investments.

e. Training and education can help with coordinating different government departments and policies.

Providing strong policy guidance is crucial to implementation.

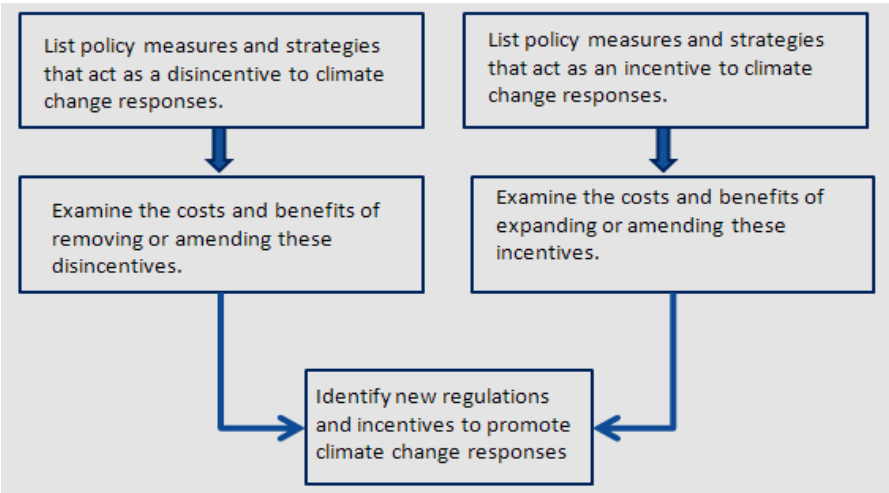
Table 7: Examples of Policy Instruments for GHG Abatement

Instrument	Definition
Regulations and Standards:	Specify abatement technologies (**technology standard**) by specifying production methods, or minimum requirements for pollution output (performance standard) to reduce emissions through establishing specific environmental outcomes per unit of product.
Taxes and Charges:	A levy imposed on each unit of undesirable activity by a source e.g. carbon tax for energy use and pollution charges for water.
Tradable Permits:	Also known as marketable permits or cap-and-trade systems. This instrument establishes a limit on aggregate emissions by specified sources, requires each source to hold permits equal to its actual emissions, and allows permits to be traded among sources.
Voluntary Agreements:	An agreement between a government authority and one or more private parties to achieve environmental objectives or to improve environmental performance beyond compliance to regulated obligations. Not all voluntary agreements are truly voluntary; some include rewards and/or penalties associated with joining or achieving commitments.
Financial Incentives:	Direct payments, tax reductions, price supports, or the equivalent from a government to an entity for implementing a practice or performing a specified action.
Information Instruments:	Required public disclosure of environmentally related information, generally by industry to consumers. Includes labelling programs and rating and certification.
Research and Development (R&D):	Direct government spending and investment to generate innovation on mitigation, or physical and social infrastructure to reduce emissions. Includes prizes and incentives for technological advances.
Non-Climate Policies:	Other policies not specifically directed at emissions reduction but that may have significant climate-related effects.

Source: UNDP (2008): National policies and their linkages to negotiations over a future international climate change agreement An Environment and Energy Group Publication

Institutions and Policy Instruments

The attempt to meet policy goals involves more than just identifying instruments that reduce the targeted effects. It also involves making tradeoffs between interests and values commonly held by policy makers, administrators, the regulated community and the public at large. The introduction and adoption of policy instruments will depend on the institutional practices and arrangements of the government of Rwanda. This is because it is the institutions that structure both the policy development and instrument adoption. Therefore the nature of the Climate Change problem or challenge and the characteristics of the instruments are important.



Regulatory and Incentive Based Strategies

Government regulation as an "art and craft" of choosing and developing instruments of intervention and an institutional reality, requires consideration of; the political context and the established institutional rules, roles and practices. Institutionalised rules and practices define the modes and tools of government intervention. The development of specific tools is conditioned by the complexities of the demands upon institutional actors and by the allocation and management of resources, competencies and administrative capacities.

Source: King (2010): Mainstreaming Climate Change – a Guidance Manual for the Pacific Islands Countries and Territories
Figure 13: Summary of Mainstreaming Regulatory and Incentive Based Strategies

4.3 Entry Points for CCMA for the Energy sub-sector

Although adaption to climate change represents a new challenge, there are overlaps that do exist between business-as-usual development strategies and adaptation. In a number of cases, activities undertaken to achieve development objectives can automatically lead to adaptation benefits. For instance, decisions taken as part of development activities can have considerable bearing on the vulnerability of societies to the potential impacts of climate change. In principle, a range of development activities oriented towards reduced poverty and improved nutrition, education, infrastructure and health would be synergistic with adaptation to climate change. This is the fundamental principle of adaptive capacity as discussed in the IPCC (2007 and 2001): that better developed societies possess more adaptive capacity than less developed societies and therefore have lower vulnerability to climate change.

Policy and strategy processes

Energy and infrastructure development are based on existing natural resources endowment, driven by social and economic development processes, and shaped by technological developments. Hence, cross-sectoral policies (strategic developments in sectors on which energy and infrastructure projects depend) provide the first and main entry points for mainstreaming climate change adaptation and/ or mitigation.

4.4 Entry points and adaptation in transport sub-sector

All the 5 transport Sub-Programmes Institutional and Human Resource Capacity Building, Development of Infrastructure for opening up the country, Development and Maintenance of Road Transport Infrastructure, Regulation and Road Safety and Control of Transport Costs provide entry points for mainstreaming CCMA(Transport Sub-Sector Strategic Plan 2008-2012).

The transport infrastructure in Rwanda comprises of the following:

(i) Road transport: A large programme to expand and maintain roadnetworks has been developed. , which until now is the main form of passenger and goods transportation, with a network of about

(ii) Air transport with two international airports and six aerodromes spread across the country, and

(iii) Lake transport, which is limited mainly to the Lake Kivu,

(iv) Transport services, which are provided by the public and private sector alike

(v) Railway system which Rwanda plans to develop through the southern route connecting with Isaka dry point in Tanzania, Burundi (at Gitega) and the DRC. Transportation costs in Rwanda are

estimated to contribute to more than 40% of the total value of imported or exported goods respectively as compared to between 6.5 and 11% in developed countries (Transport Sub-Sector Strategic Plan 2008-2012).

4.4. Opportunities and Entry Points within Water Supply and Sanitation Services

Strategic policy objectives

The Strategic Action Plan for the WSS Sector policy statements for the WSS services offer opportunities for entry points in addressing CCMA. Examples include;

Table 8: Mainstreaming CCMA within the Water supply and sanitation services

Strategic Objective	Key Climate change concerns/impacts	Adaptation Actions	Required tool(s)
1.Raise rural water supply coverage by assisting the Districts to plan, design, finance and implement infrastructure projects			
Ensure sustainable functionality of rural water supply infrastructure by developing effective management structures	Systemic losses could increase as pipes and supply systems wear & tear under extreme weather conditions		
Enhancing storm water management to mitigate impacts on properties, infrastructure, human, health and the environment. Improvements in storm water management need cooperation with other sectors in the fields of urban planning, erosion control and environmental health.	Storm water runoff causes a range of negative impacts including erosion of lands, damages to infrastructure, environmental health hazards and pollution of water resources.		
Development of the sector's institutional and capacity building framework in particular developing professional training and education in WSS relevant fields,			
Extend Water supply and sanitation infrastructure to "*imidugudu*" sites identified by the decentralized institutions	Site appropriateness		
Promotion of public – private partnership in water & sanitation services provision			

Opportunities within the Water Supply and Sanitation management value chain

4.5 Opportunities within the Cross-sectoral Policies and Strategies

All energy and infrastructure sectors are service-provision oriented or secondary sectors. The effects of climate change in these sub-sectors arise often arise from other sectors and the cost and effectiveness of adaptation may be a barrier unless they influence the various sectors. Examples are:

1. Water comes from the watersheds, and if the so called blue water" does not flow, nothing will go into the pipes, whatever the design, or how power the pumping machine is.
2. Some transport challenges –e.g. soil erosion silting or flooding cannot fully be addressed by re-designing the culverts of road turnouts. There has to be collaboration to fix soil and land management upstream.

5. Guidelines and Tools for Mainstreaming Climate Change Adaptation and Mitigation in Energy and Infrastructure Sectors

"…communities around the world need better weapons - new tools, techniques, and strategies - if they hope to tame the three-headed hydra of climate risk, poverty, and precipitous urbanization...." Judith Rodin, President of The Rockefeller Foundation

5.1 Assessing Climate Change Vulnerability

It is important to ask 3 important questions:

1) How can/is climate change likely to affect energy use among households and corporate consumers?
2) How will/might climate change impact energy production and supply in Rwanda?
3) How should the present policy and strategic interventions in the energy sector adapt to minimize the likely climate change effects?

These same questions should be asked in the building sub-sector, as climate change is likely to affect household and business energy needs, costs and demands. The energy supply institutions and sources will likely face increasing stresses on how to deliver more at less cost, with dwindling natural resource base.

Need to generate sufficient evidence on how climate change could affect energy production and supply, as extreme weather events become more intense; which types of energy sources and geographical areas are more vulnerable; and what levels of power generation/energy production efficiency are required address the needs and cope with the climate change challenges especially to keep the rising costs reasonable.

Recommended actions

- Establish a clearinghouse for information on transportation and climate change; the establishment of a research program to re-evaluate existing design standards and develop new standards for addressing climate change; creation of an interagency working group on adaptation; changes in federal regulations regarding long-range planning guidelines and infrastructure rehabilitation requirements; and re-evaluation of the National Flood Insurance Program and updating flood insurance rate maps with climate change in mind.
- Vulnerability assessment should underpin any proposed changes to the national economic plans and programmes as the most vulnerable communities, ecosystems and

infrastructure should be given priority for protection. Vulnerability assessments are key tools for the development of climate change adaptation strategies. Some of the key motivations for carrying out vulnerability assessments include:

- Helping in setting management and planning priorities
- Assisting in informing and crafting adaptation strategies

5.2Mainstreaming Climate Change at the National level

In order to mainstream Climate Change at the National Level, the OECD recommends the following steps;

i) Identify and engage key national actors;
ii) Improve access to national level climate information;
iii) Organize government structures to better address adaptation;
iv) Build on and reinforce existing national mechanisms for disaster risk reduction;
v) Modify regulations and standards to reflect current and anticipated climate risks;
vi) Enhance linkages between multilateral/ regional commitments and adaptation. Mainstreaming needs to integrate adaptation into the entire policy cycle, policy formulation stage, planning stage, resource allocation stage, and programming/implementation stage.

Mainstreaming in the sector budget

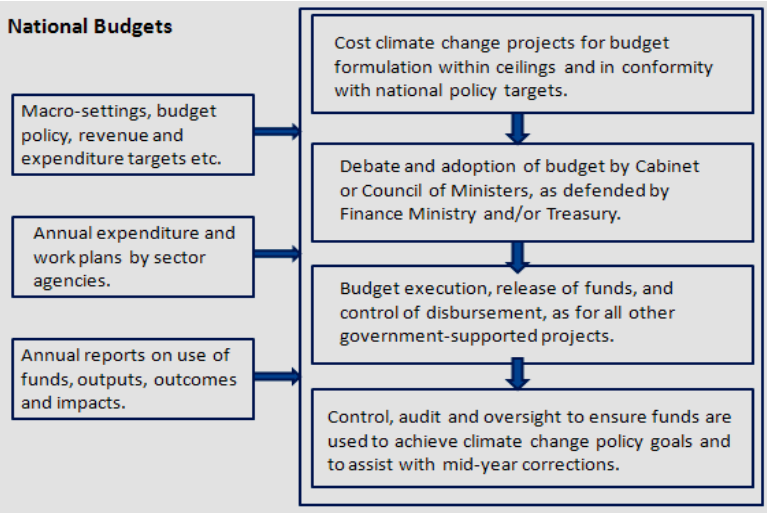
The budget process is how government expenditures are determined or allocated. It consists of four main stages: formulation, adoption, execution, and control, audits and oversight. National budgets are usually formulated by a two-way flow of information to and from sector agencies, coordinated by the Finance Ministry, possibly under the command of a budget committee at Cabinet or Council of Ministers level. The main stages in budget formulation are the macro-economic basis, budget policy outline, preparation of revenue and expenditure targets, and submission of sector plans within those ceilings. Adoption is by Parliament or by Cabinet and endorsed by Parliament.

For effective mainstreaming within the budget, all key stakeholders need to be targeted with climate change information, viz:
National Planning and Finance Authorities: MINECOFIN has the final say on vote allocation and should be familiar with the priorities;
Parliament is the key accountability and oversight institution with authority to pass the sector budget and approve accountability reports. They (especially Commissions on National Economy, infrastructure and Natural Resources) should be sensitised on the links between infrastructure targets and climate change effects.

The importance of integrating climate change into annual budgets is to (i) ensure that adequate resources are allocated to high priority mitigation and adaptation measures; (ii) raise additional revenues from taxes, tariffs, and pollution charges related to climate change response measures; (iii) ensure that the unintended

effects of budgeted activities in non-environmental sectors don't exacerbate climate change problems; and (iv) balance internal and external sources of funding for climate-related activities (King 2010).

Five ways that climate change could be better integrated into annual budgets include (i) increasing or introducing climate-based taxes and charges (like a carbon tax or pollution charges); (ii) increasing climate-based subsidies (e.g. for investment in renewable energy) and budget allocations for those subsidies; (iii) removing or redesigning perverse taxes and subsidies that exacerbate climate change; (iv) increasing budget allocations and tax rebates for activities with favourable climate effects; and (v) stipulating climate-based limits or goals as budget rules to govern resource allocation. Green procurement by government agencies may also provide the necessary seed funding for new and innovative technologies.

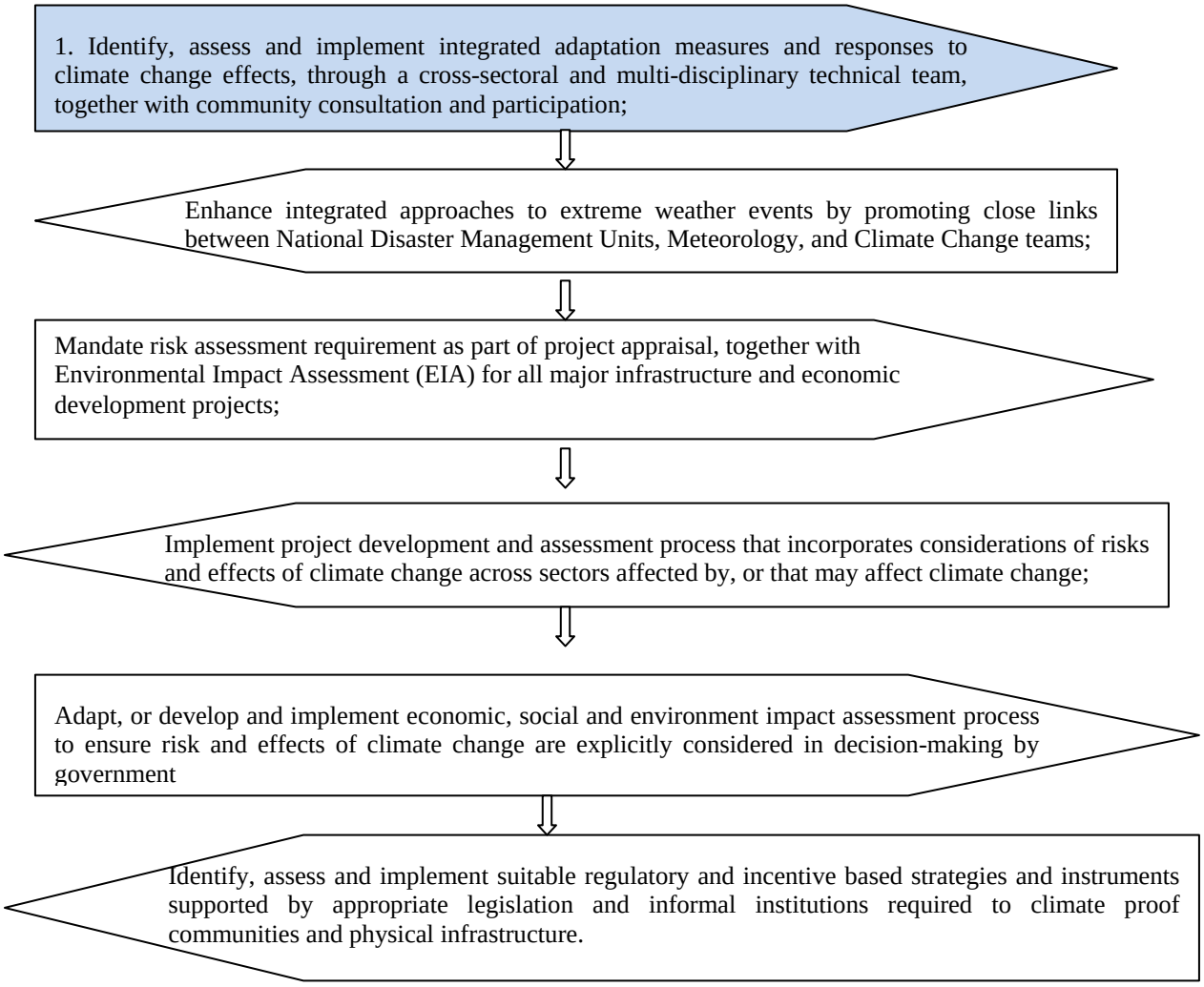


5.3Mainstreaming at the Sectoral Level

Mainstreaming at the strategic level addresses the organisational environment in which policies and programmes are developed and implemented. Mainstreaming climate change adaptation successfully requires that clear policies on adaptation are developed in broad consultation with staff and supported by senior and middle management. Strategies to implement climate change policies need to be developed, and mechanisms that ensure that staff are supported and understand the implications for their everyday work, and have the competencies and resources required to implement strategies effectively must be developed (CARE 2009).

Typically, sector agencies are expected to develop medium term sector strategies, (which may be summarized in the national development plan), as well as annual plans, which are used for budget submissions. Climate change considerations need to be built into both medium term and short term sector strategies and plans.

Figure 3: Climate Change Vulnerability Assessment in the Energy/ Infrastructure sector



Summary of Opportunities for Climate Change Mainstreaming at Strategy level

Table 9: Incorporate the following 3 core elements in the Urbanism and Housing Sub-sector Strategy:

Strategic Objective	**Opportunity & action**	
Build capacity of the urbanism & housing sub-sector to plan, finance, coordinate, and implement climate change resilience strategies.		
Stakeholders within the Urbanism sub-sector (at national and specific city/urban area level) have a functioning network that serves as a platform for a broad range of actors – urban authorities; independent Planners & builders; civil society; donors, private sector, technical partners, to engage and mutually identify and solve key climate change resilience problems		

Expansion, deepening of experience, scaling up New and more diverse partners provide resources and funding for replication in current and new cities to support the implementation of resilience plans and strategies.		

5.4Project Level Adaptation Processes

At the project level, the United States Agency for International Development identifies six main steps in mainstreaming adaptation into development planning (USAID 2007):

1 **Screen for vulnerability:** Is the project likely to be affected by climate variability or climate change? What are the potential changes in climate parameters and, therefore, climate impacts? Which sectors or project activities are likely to be affected? Which project stakeholders are likely to be the most vulnerable? If the project is not assessed as vulnerable, then no further action need be taken.

2 **Identify adaptation options:** If the project is vulnerable, compile a list of possible adaptation options in a participatory manner and reach agreement on selection criteria. Eliminate options that are not feasible in the context of the project. Shortening the list to a few key interventions will assist in simplifying the next step.

3 **Conduct analysis:** Evaluate each option for its effectiveness in building resilience to climate change in the affected communities, as well as its fit for the budget and timeframe. A performance baseline needs to be established and then compare "without" and "with" provision for adaptation. Performance criteria, possibly weighted according to importance, could include;

- **a.** Costs of action and inaction;
- **b.** Effectiveness (benefits, damages mitigated, lives saved etc.);
- **c.** Ease of implementation;
- **d.** Acceptability to local and other stakeholders;
- **e.** Endorsement by experts, in accordance with international good practice;
- **f.** Timeframe for implementation;
- **g.** Implications for the current climate;
- **h.** Number of beneficiaries; and
- **i.** Institutional capacity (need for capacity strengthening, technology and knowledge transfer). A matrix comparing options may be useful at this stage.

4 **Select course of action** – Use the results from step 3 to carefully select the most appropriate interventions, bearing in mind that funding agencies might have differing priorities than national governments, so "buy-in" from all key stakeholders is crucial. Selection factors must be in the context of the country's own economic, social and environmental goals, not just the needs of the project.

5 **Implement the adaptations** – Implementation of adaptation interventions should follow the normal project processes – better definition of specific tasks, time schedule, roles of implementing partners, resource requirements, and fund mobilization. The identified capacity strengthening and training will also need to be undertaken at this stage. A plan for monitoring and evaluation will also need to be formulated, to undertake step 6.

6 Evaluate the adaptations – Monitoring and evaluation will determine if the project or adaptation intervention has delivered the intended benefits, or if it has caused unintended adverse impacts. As climate change may be more of a long-term risk, the lack of an immediate pay-off may make the climate change benefits more difficult to evaluate. In such cases, short-term success criteria may be needed, such as ease of implementation, no-regrets benefits (valuable benefits even if the climate doesn't change as expected), and strengthened institutional capacities. If the project has not achieved its objectives or has caused unintended adverse impacts, it may be necessary to return to step 3 and re-assess adaptation options, select new adaptations, or modify the current set of adaptations.

As adaptation planning and implementation is relatively new, an additional role of evaluation is to assess the process itself, so that future planning and implementation of adaptation measures are improved.

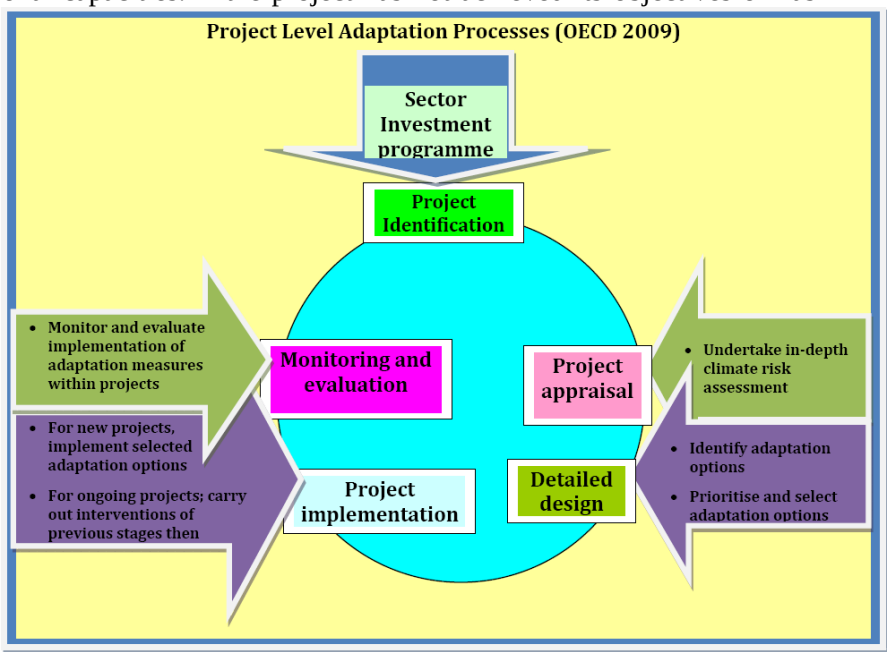


Figure 16: Project Level Adaptation Processes

5.5 Integrating Climate Change adaptation at the local level

Many, if not all, adaptation measures need to be implemented at the local community level. "Adaptation will ultimately be a localised phenomenon. It will be driven by the need for people to adapt to the local manifestations and impacts of climate change, which will be mediated by geography and local physical, social, economic and political environments". In many ways, local communities have been adapting to climate variables for generations, yet they are peculiarly ill-prepared to deal with climate change as a global issue over which they have little influence (King 2010). Mainstreaming climate change adaptation at the operational/local level aims to:

a. Examine the vulnerability of development programs and projects to the current and future climate risks
b. Assess the extent to which such projects already consider and manage such risks
c. Evaluate potential adaptation measures to address remaining risks

The seven-step approach for mainstreaming climate change adaptation at the operational level, known as the Climate Vulnerability and Adaptation Pathway (CVA Pathway), follows a development path parallel to the project cycle. The table below illustrates the relationship between the project cycle and the CVA Pathway, and the tools available to practitioners to complete each step.

Table 10: Steps and Tools Climate Vulnerability and Adaptation Pathway

Project Cycle	Climate Vulnerability and Adaptation (CVA) Pathway
Analysis	**STEP 1: Screen project activities for climate risk** Using a summary of climate trends, forecasts and impacts undertake a preliminary assessment of whether climate variability and change could impact the effectiveness, longevity, and integrity of your project.
	Tools: *Tool* A: Assess Climate Risk **Participants:** Programme and component managers and project officers.

	Key Outcome: A detailed table of the main climate change impacts that will affect project activities and results
	STEP 2: Decide on the CVA Pathway If Step 1 indicates that climate impacts are likely to affect your project, you will need to decide whether to follow the CVA pathway, taking into account any existing risk management practices, **Tools:** ***Tool* B Checklist:** Should we follow the CVA Pathway? **Participants:** Programme and component managers and project officers. **Key Outcome:** List of projects which will progress through the remaining steps of the CVA Pathway.
Design	**STEP 3: Identify Adaptation Measures** Once you have decided to follow the CVA Pathway it is expected that you will work closely with implementing partners, local decision makers and stakeholders, to identify a wide range of potential adaptation measures for tackling climate change risks and opportunities for strengthening adaptive capacity. This will involve reviewing available information and using participatory tools. **Participants:** Component managers, project officers, partner organisations and community members. **Key Outcome:** A list of potential adaptation measures for reducing climate risk and strengthening adaptive capacity.
	STEP 4: Prioritise Adaptation Measures Prioritise potential adaptation measures to address the vulnerabilities identified in Step 1. Prioritising adaptation measures must also consider project timeframe, budget, and the technical requirements of implementing different adaptation measures. **Participants:** Programme and component managers, partner organisations and project officers. **Key Outcome:** List of criteria for determining benefits and feasibility of adaptation measures; and a list of adaptation measures ranked in order of priority.
Implementation	**STEP 5: Select Adaptation Option(s) for Implementation** Using the results from Step 4 work with partner organisations and community members to select which adaptation option/s will be implemented. This will involve developing local ownership of the process and decided measures. **Tools:** Stakeholder Workshop Methodology **Participants:** Project officers, partner organisations and community members. **Key Outcome:** Adaptation measures(s) selected by the community and community support and consensus.
	Step 6: Implement Adaptation Measures This is the step when project activities are undertaken, stakeholders and partners are actively engaged, the capacity of project stakeholders is built and the project is monitored and adapted to any new conditions that may arise. **Participants:** Project officers, partner organisations and community members. **Key Outcome:** Community-based adaptation measures are implemented.
Monitoring & Evaluation	**STEP 7: Evaluate Adaptation and the CVA Pathway** Once you have implemented the adaptation measures the final step is to evaluate them. The purpose of evaluation is to determine whether the project or program 1) delivers the intended benefits and/or 2) causes any adverse outcomes. Evaluation also provides the opportunity to reflect on the overall CVA pathway and ways it might be improved. Lessons learned should be documented and shared in applied case-studies so as to inform future project design and implementation. **Participants:** Programme and component managers and project officers **Key Outcome:** Organisational sharing and learning and applied case-studies

Adopted from CARE International Vietnam (2009)

Implement public-private partnership in formulation and implementation of new building standards: Clearly climate change mitigation and adaptation are not the sole preserve of governments, as most activities which impact on the climate or, in turn, are impacted by a changing climate take place in civil society. Many promising climate change responses, especially in relation to mitigation, will involve the private sector, such as energy efficiency gains in industry, retrofitting buildings to conserve energy, and renewable energy providers. Governments can assist the private sector in taking up these activities through various incentives like green procurement and through public-private partnerships. Governments can also involve the private sector through multi-stakeholder processes and consultations, as well as adding private sector representatives to key committees and national councils.

One key area where private sector involvement is essential is in amendments to national codes and standards, such as the engineering standards and building codes. Often the best method is for the Government to set a specific target and request the private sector to find the best ways of achieving that

target. Standing committees may be formed to regularly review such standards and codes as additional information on climate change predictions becomes available. Governments should insist on such standards for any donor funded infrastructure or buildings.

At the community level, NGOs have proven to be effective intermediaries between the government and the community. Governments should encourage active civil society involvement in all areas of climate change responses. Local and international NGOs may be particularly helpful in documenting and codifying traditional and indigenous adaptation measures, which may hold the key to future adaptation measures. Environmental NGOs can contribute considerable experience in ecosystem-based approaches to climate change adaptation to facilitate less vulnerable and more resilient communities.

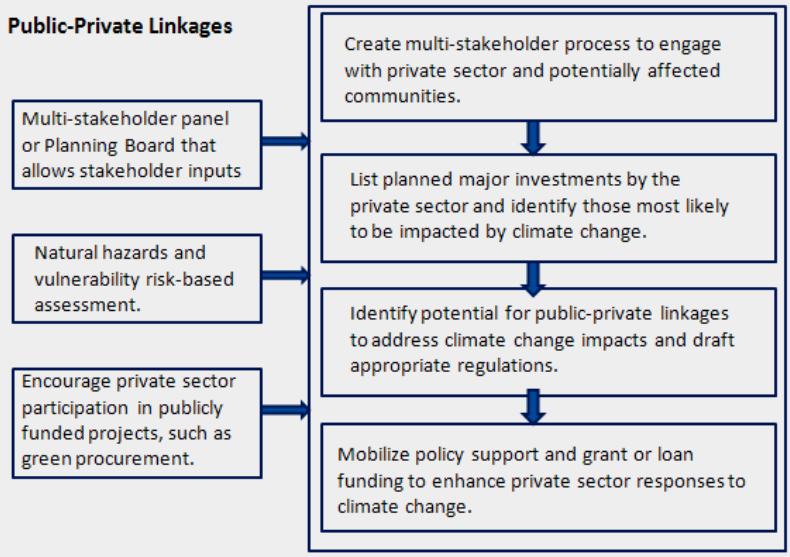
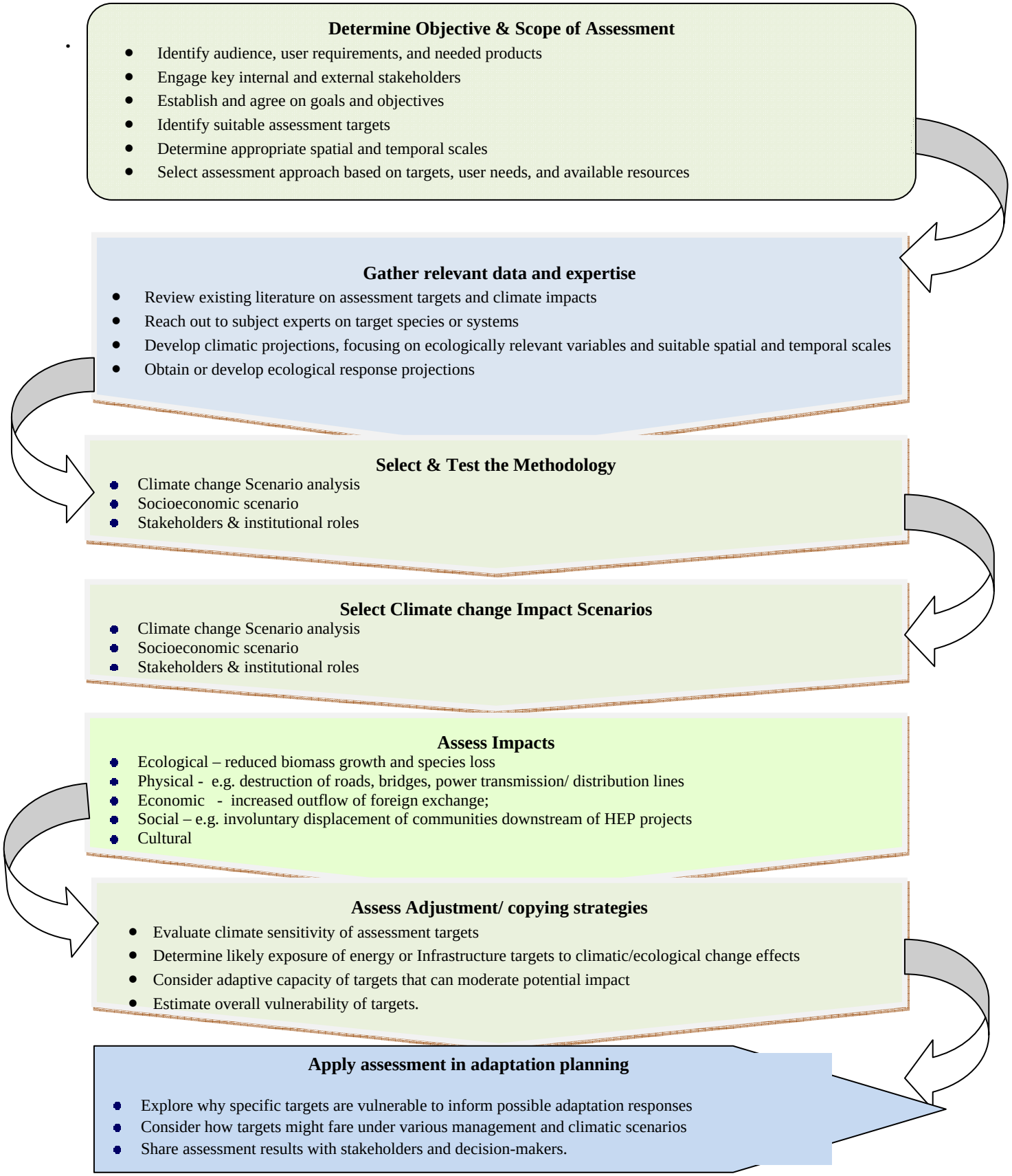


Figure 17: Mainstreaming Public-Private Linkages to Address Climate Change Source: King (2010)

Figure 4: Summary of the Steps for Assessing Vulnerability to Climate Change in Energy & Infrastructure Sector



Climate Change Risk and Vulnerability Assessment should underpin any proposed changes to the national economic plans and programmes as the most vulnerable communities, ecosystems and infrastructure should be given priority for protection.

5.6 Barriers to Mainstreaming Adaptation to Climate Change

Lack of awareness of climate change within the development community and limitations on resources for implementation are the most frequently cited reasons for difficulties in mainstreaming adaptation to climate change within development activity. These explanations may hold true in many situations but there is also a more complex web of reasons underlying them:

a) ***Barriers within governments and donor agencies***: Climate change expertise is typically the domain of environment departments in governments and donor agencies, and such departments have limited leverage over sectoral guidelines and projects. Sectoral managers and country representatives may also face "mainstreaming overload", with issues such as gender, governance and environment also vying for integration in development activities. Moreover, as many development projects are funded over three to five years, they may not be the best vehicle for long-term climate risk reduction. Adaptation to climate change ex ante may also have more difficulty attracting resources than more visible ex-post activities such as emergency response and post-disaster recovery.

b) ***Insufficient relevance of available climate information to development-related decisions:*** Development activities are sensitive to a broad range of climate variables, only some of which can be reliably projected by climate models. Temperature, for example, is typically easier to project than rainfall. Climate extremes, which are often critical for many development-related decisions, are much more difficult to project than mean trends. There is also a mismatch between the time and space scales of climate change projections and the information needs of development planners. For example, the primary sensitivity of development activities to climate is at a local scale (such as that of a watershed or a city), for which credible climate change projections are often lacking.

5.7 Opportunities and Actions for effective implementation of Adaptation activities

1. **Make use of existing/emerging policy dialogue platforms:** The National Urban Forum established on recommendation of the National Seminar on sustainable urbanization and housing in Rwanda held in October 2007, gathers all the partners of the urban development in Rwanda. It is a space of dialogue between various partners of the urban sector in Rwanda in order to stimulate synergies for the harmonious management of the urbanization and of sustainable development of the country. These platforms will also assist to promote coordinated planning and implementation of climate change adaptation activities that are inherently cross-sectoral.[2]
2. **Documenting and leveraging good practice demos** that have been undertaken within the clean energy initiatives as well as local actions in water infrastructure management.
3. **Synthesise existing data and information into refined policy messages.** Making climate change information on climate change more useful and easier to use, is as important as the quality

[2] In the housing sub-sector, for example, the main climate change issues relate to energy, water and waste management, as well as transport and safety. Most challenges will require adaptation in other sub-sectors.

of information provided. In the infrastructure sector, one has to be careful to differentiate climate change issues from environmental issues because they are often confused to be the same.

4. **Appropriate tools:** All tools and approaches suggested need to be piloted across different geographical areas and scale and continuously adjusted until the fit into specific sectoral or geographical circumstances. Planners and Practitioners should not struggle to use otherwise inappropriate tools (e.g. by way of cost, complexity or convenience) especially for climate change risk screening which are the initial and most important stages of the Adaptation process. Nothing should be perceived as cast in stone or blueprint.

5. **Appropriate Entry points, including timing:** There is a need to identify the appropriate points at which to introduce climate change adaptation in the development activities. Potential entry points include land use planning, disaster response strategies and infrastructure design. Environmental impact assessments could be another entry point for mainstreaming both climate change mitigation and adaptation. The implications of projects for GHGs could be included in checklists for such assessments. However, guidelines for environmental impact assessments would need to be broadened to include climate change impacts. Current EIA guidelines consider only the impact of a project or activity on the environment, not the impact of the environment on the project. It is also important to incorporate climate change considerations in planning mechanisms and to ensure that the responsibility for co-ordination lies with appropriate implementation agencies.

6. **Focus on the long-term**. Hence, go beyond the strategy, action plans or investment budgets. Effective climate change adaptation will happen if climate change issues are incorporated in legislation and standards e.g. the Building standards or road construction protocols.

7. **Provide sufficient detail**: all the steps should be considered. It would be better to consider and analyse even the costs of adaptation so that decisions are not dropped on the way and to encourage a range of options for response. The tendency to focus more on the science and forget the politics and economics of climate change adaptation should be avoided. This also relates to the importance of providing relevant, simple and practical information on the risks, vulnerabilities, adaptation options and expected results.

Table 11: Summary of Climate Change Vulnerability and Potential Adaptation and Mitigation Measures by Sub-sector

Sector	Climate Change Impacts and Vulnerability Issues	Potential Adaptation Measures	Potential Mitigation Measures
Hydro Power	• Prolonged droughts, which were a result of Climate Change, reduced the water levels significantly both in the rivers and the Lakes. This affected power generation forcing the government to increase thermal electricity generation, with its accompanying negative environment effects and high cost per unit of power. • Increased outages and load shedding Negative impact on economic growth • Less capital available to diversify power generation options (cogeneration, wind, geothermal and small hydropower) • Climate Change also is likely to affect infrastructure for energy production, transmission and distribution. The transmission systems of electric utilities may experience a higher rate of failure, with attendant costs. This phenomenon, will greatly affect energy security and economic development activities.	• Restoration and sustainable management of Water sheds, • Integrate Climate Change considerations into the management and operation of hydroelectric power generation, transmission & distribution systems • Promote the integration of vulnerability and adaptation to Climate Change into energy and sustainable development plans and processes in Rwanda. • Develop and promote environmentally friendly alternative energy sources like Biomass gasification technologies for power generation and solar power for lighting and refrigeration. • Replacing incandescent bulbs with low energy consumption • Set and enforce design standards for the hydro power infrastructure to cater for the effects of climate change and variability.	• Promote efficient practices in the utilisation of hydro power like the promotion of Compact Fluorescent Lamps (CFLs) and promotion of Good Domestic and place of work energy management • Promote tree planting activities, • Optimise the utilisation of naturally generated Methane for energy through biogas technology • Conduct regular energy audits as indicated in the energy policy 2008-2012
Biomass	• Prolonged droughts may affect regeneration potentials and growth rates of some wood fuel species and may also affect the planting of trees, thus affecting supply, • Climate change will make forest management more difficult due to increases in pests and fires. • Fuel wood products will become expensive	• Promote draught resistant tree species for fuel wood production • Efficient conversion technologies like improved charcoal production kilns and retorts, • Biomass gasification technologies for heat and power production, • Improving biomass fuel management and utilisation practices e.g. improved cook stoves	• Promote profitable Tree planting for fuel wood production • Set standards for Biomass energy production and marketing to facilitate monitoring and enforcement of sustainable practices. • Set and monitor standards for biomass technologies (Stoves, Kilns, Retorts, Gas burners) • Set standards and conditions for land use. • Research and development
Peat	• When peat-lands are drained and developed, they stop absorbing carbon dioxide, • Also of interest is the fact that the emissions of methane, which is a worse gas than CO_2 in causing Climate Change, ceases. • When peat is harvested and used as a fuel the stored carbon is released back into the atmosphere as carbon dioxide.	• Set standards for harvesting and processing of peat as a fuel • Set guidelines and conditions for use of marshlands and excavation of peat.	• In the post production phase, the cutaway peat-lands can be reclaimed for forestry, or restored to Wetlands, and once again become carbon sinks. • Promote efficient peat energy utilisation technologies like gasification technologies
Sector	**Climate Change Impacts and Vulnerability Issues**	**Potential Adaptation Measures**	**Potential Mitigation Measures**
Petroleum	• Unreliability of fuel supplies due to affected roads as a result of climate related disruptions. This leads to transport and production disruptions	• Efficient utilisation technologies • Application of affordable alternative renewable fuels (Bio-energy) • Construction of storage facilities	• Set and enforce a strict code of standards for procurement and storage • Establishing carbon sinks (Tree planting) • Develop and or improve distribution infrastructure

		• Store fuel according to its origin of import or according to the quality required by Rwanda Bureau of Standards and Rwanda Environment Management Authority	• Invest in renewable energy technologies • Conduct regular energy audits as indicated in the energy policy
Natural Gas		• Promoting efficient conversion and utilisation technologies • Promotion of alternative renewable fuels like biogas • Research and development	• Set efficiency standards for equipment that uses natural gas. • Promotion of tree planting • Conduct regular energy audits • Research and development
Agricultural and Forest and Urban Garbage Wastes	• Prolonged draughts will affect agricultural productivity and this will impact on the available agro-wastes for energy. • Water shortage or floods will impact on production of biogas. • Floods will affect the urban garbage dumps and could be a source of epidemics	• Promotion of efficient stoves • As a mitigation measure at the global level, and an adaptation measure at the household level, garbage dumps could be designed as landfills to capture the Land Fill gas (CH_4) as an alternative energy source for domestic and industrial application.	• Promotion of microbiological energy systems for Biogas and Landfill technology for methane production • Thermal chemical conversion of some waste into energy using gasification technology.
Water	• Prolonged droughts lead to lowering of lakes' and rivers' water levels which reduce access to water by households, for drinking and hygiene • Loss of associated biodiversity. • Decreases agricultural productivity • Worsens the food security situation due to crop failures and poor performance of traditional species, malnutrition and poor health • Water scarcity may result into conflicts for the water itself and pasture. • Further reduction of water Lowering efficiency of sewerage systems > more micro-organisms in raw water supply • Increased concentration of pollutants (less dilution) • More overflows in sewerage systems with increased precipitation > spread of waterborne diseases • Increased salinity water resources.	• Working on the maintenance, major rehabilitations and re-engineering of existing systems (for example, dams, barrages, irrigation systems, canals, pumps, rivers, wetlands). • Develop a water quality surveillance system for rural water supply • Promote water purification technologies for household water and desalination facilities • Strengthen community based maintenance system for rural point water sources • Encourage rainwater harvesting for household application, • Rain water harvesting for production and animal husbandry • Water conservation practices and recycling. Loss reduction, leakage control, conservation plumbing, construction of new reservoirs, • Improve operational efficiency and reduce unaccounted-for water	• Plan and apply new investments (for example, reservoirs, irrigation systems, capacity expansions, levees, water supply, wastewater treatments, and ecosystem restoration). • Land use planning and Water shed management, • Promoting Tree planting • Develop and set water management standards • Loss reduction (leakage control; conservation plumbing) • Capacity increase (new reservoirs, desalination facilities) • Water allocation (*e.g.* municipal *vs*. Agricultural, Water permits and Water pricing) • Risk management to deal with rainfall variability.
Sector	**Climate Change Impacts and Vulnerability Issues**	**Potential Adaptation Measures**	**Potential Mitigation Measures**

Transportation	• Traffic congestion in the urban centres • Loss of productive time on the roads • Air pollution • Noise pollution	• Controlling the growth of personal vehicles • Reduce costs for public transportation and give priority to public transport in cities, • 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. • Installing a fuel economy (Fuel-Max) on each motor vehicle and/or installing a catalytic converter on each motor vehicle; • Promote energy conservation and efficiency through encouraging proper maintenance of vehicles and good driving practices.	• Promote the production of affordable bio-fuels • In collaboration of Rwanda National Police and the MININFRA, prepare a project of measurement of Greenhouse gases emission from vehicles and its standards development; • Institute regular vehicle inspection • Set standards for low emissions, strengthen fuel economy technologies (which will include group/bulk transportation systems like rail transport) and promote high efficiency vehicle market penetration. • Encourage research into alternative fuels for transport purposes, such as ethanol, methanol and biodiesel.
	• Extreme floods in western Rwanda leading to destruction of roads and other infrastructure, agricultural production and houses, leaving many people homeless. • Floods which lead to runoff on steep slopes increases the cost of infrastructure/roads maintenance, with disastrous consequences for poverty reduction,	• Set new and appropriate road standards that can stand the new challenges of climate change. • Setting standards for roads and bridges construction,	• Develop an effective institutional structural mechanism for enforcement.
The Habitat and Urbanism Sub-Sector	• Climate change there are frequent flush floods which led to house destruction, • Climate change has led to the increase in the number malaria causing of mosquitoes • High temperatures lead to discomfort in the houses	• Introduce a Code for Sustainable Homes for measuring and improving the environmental performance of all buildings. Set and enforce standards for buildings to take care of climate change and variability challenges. • Establish local design review panels where developers and design teams can engage positively with local planning authorities • Facilitate Architects in research to support housing providers in finding new solutions of general application • Setting and enforcing standards for buildings to take care of climate change and variability challenges.	• Develop a standard for a balanced mix of housing type and density levels guided by a spatial strategy or spatial master plans • Set and enforce standards for low carbon building materials • Promote renewable energy technologies for cooking and lighting in the imidugudu; • The standards for the Architectural designs of houses should be mosquito proof allow for natural indoor temperature regulation • Set Standards for air conditioners in urban areas

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ANNEXES

ANNEX I: WATER SUPPLY AND SANITATION SECTOR

Vulnerability assessment in the WSS Services

It is useful to differentiate hydrologic runoff *sensitivity* to climate change from that of water management *vulnerability* and societal *susceptibility* to economic disruptions and dislocation as a consequence of climate change. Hashimoto et al. (1982a, 1982b) introduced taxonomy to account for risk and uncertainty inherent in water resources system performance evaluation. It is clear that the five terms listed below simply represent a set of descriptors that characterize and extend the key components of more traditional engineering reliability analysis, i.e. they focus on the sensitivity of parameters and decision variables to considerations of uncertainty, including some aspects of strategic uncertainty. The terms are:

1. **Reliability** – a measure of how often a system is likely to fail;
2. **Robustness** – the economic performance of a system under a range of uncertain conditions;
3. **Resiliency** – how quickly the Water Supply and Sanitation System recovers from climate-induced failure (floods, droughts);
4. **Vulnerability** – how severe the consequences of failure may be;
5. **Brittleness** – the inability of optimal solutions to accommodate unforeseen circumstances related to an uncertain future.

The relative *vulnerability* of a water resources system is, therefore, a function of hydrologic *sensitivity* as an input to the managed system and the relative performance (robustness) of a water management system as it affects the delivery of services required by society. This is more of a technically defined management function, which can be quantified according to various scenarios of climate change. Societal *susceptibility* to climate change, on the other hand, depends on numerous factors outside the control of water managers, such as land use regulations, proper allocation of water supplies and population growth and economic policies related to water uses. Without an integrated water management capability, society becomes increasingly susceptible both to population- driven increases in water demands, as well as climate change variability. In other words, susceptibility and vulnerability increases not so much because of increased hydrologic variability, but more as a function of an inadequate institutional infrastructure required to manage those resources. In many cases, upgrading the institutional capacity of developing nations to implement sound water management practices is the most effective way of reducing vulnerability due to climate change. These processes include:

a. Assess existing statutes, policies and regulations for dealing with extremes and contingencies

b. Who has the authority and responsibility for what?

c. Who is responsible for climate adaptation planning?

d. Who operates and maintains existing water infrastructure? Is it at capacity? Can it serve projected needs? What is needed over next 10–20 years?

e. Assess socioeconomic scenarios of growth and development – what does the future look like? How will future demands for resources be met? What is the role of water?

f. Assess vulnerability to current climate variability – floods and droughts. How will this change under future climate scenarios and growth?

ANNEX II: TRANSPORT INFRASTRUCTURE

Risk Assessments on Transport Infrastructure

Incorporation of climate change impacts into transportation decisions is still a relatively new concept. As decision makers in various sectors grapple with information on climate change effects and how they may or may not impact their core mission(s), they are turning to existing tools and approaches for guidance. To date, three closely-related approaches are being used to help transportation decision makers consider and prepare for future climate impacts: vulnerability assessment, risk assessment, and adaptation assessment.

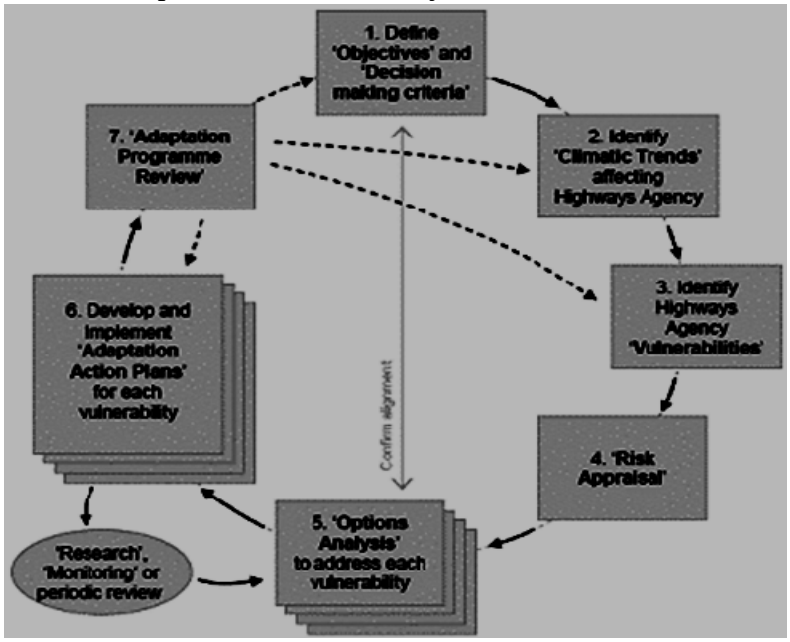
Vulnerability assessment begins with the identification of existing stressors facing transportation systems and projects how climate change will impact and/or introduce new stressors in the future. The findings of the assessment can then be ranked to assess, prioritize, and address vulnerabilities.

Risk assessment evaluates the likelihood and consequence of climate-related impacts on transportation and can be rooted in engineering applications. Many times this assessment will quantify the product of the probabilities of exposure and vulnerability. This assessment provides transportation policymakers with guidance based on quantitative analysis of the level of risk associated with changing climate conditions.

Adaptation assessment identifies plans, prioritizes, implements, and measures transportation management options available for effectively adapting to climate change impacts. This assessment may discuss ways to reduce transportation vulnerability, increase resilience and/or highlight regions of retreat.

These approaches have been applied at varying levels of sophistication in assessing climate change impacts on human and natural systems. This document details how these approaches have been or could be used to integrate climate change impacts into transportation decisions and ultimately increase the adaptive capacity of the highway system.

A sever-phase process for assisting transportation decision-makers in addressing climate change impacts on highways is summarised in figure 10.



Modified from HACCAS (2008): Seven-phase process for assisting transportation decision-makers

In step 4; each vulnerability identified receives a risk-ranking based on a risk appraisal scoring using four primary criteria: (1) uncertainty, (2) rate of climate change, (3) extent of disruption, and (4) severity of disruption (see Table below for scoring criteria).

Primary risk criteria	Risk Source	Risk Score (numerical)
Uncertainty	Low	1

Rate of Climate Change Criterion	Medium	2
Extent of Disruption	Medium	2
Severity of Disruption	High	3

Source: U.K.HACCAS, 2008

Step 5 and 6 then prioritize the results of step 4 determining the timescales for action and highlighting the priority areas requiring early involvement through adaptation strategies (see Table below).

Prioritisation Criteria	Indicator score
Time-criticality	**2/3=0.67**
High Extent	**2/3=0.67**
High disruption duration	**3/3=1**
Potential research need (asset or activity)	**1/3=0.33**
Highly disruptive, time-critical with high confidence	**[2x2x3x(4-1)/81=0.44**

Source: U.K. HACCAS, 2008

Checklist for Determining Appropriate Adaptation Actions

a) **What is the timeframe of risks?** The timeframe for projected impacts (e.g., short-term, mid-term, long-term) can be assessed relative to the timing of management decisions and actions. The severity and probability of projected impacts can also be factored into this analysis . Compare with the timeframe available for implementation of action.

b) **What are the cost-benefit considerations?**

c) **Are there any constraints or limitations?** How could these affect the decision-making process? Categorise the limitations on the basis of nature i.e. whether they are regulatory, operational, political, or legal.

ANNEX IV: DEFINITIONS AS USED IN THE GUIDELINES

i) **Climate Change** refers to ongoing changes in the global climatic system resulting primarily from anthropogenic global warming as a consequence of the increased and continuing emissions of greenhouse gases and the loss of vegetation cover and other Carbon sinks. It refers to gradual changes in climate norms, notably temperature, and changes in the frequency, extent and severity of climate and weather extremes.

ii) **Vulnerability** is a set of conditions and processes resulting from physical, social, economic, and environmental factors, which increase the likelihood that a community will be negatively affected by a climate hazard or change. It is a combination of exposure to climatic conditions, how sensitive the community is to those conditions, and the capacity to adapt to those changes.

iii) **Climate Change Adaptation** refers to spontaneous or organised processes by which human beings and society adjust to changes in climate by making changes in the operation of land and natural resource use systems and other forms of social and economic organisation in order to reduce vulnerability to changing climatic conditions.

iv) Adaptation Policy Framework (APF) is an assessment, planning and implementation framework, which lays out an approach to climate change adaptation that supports sustainable development, rather than the other way around. The APF is about practice rather than theory; it starts with the information that developing countries already possess concerning vulnerable systems such as energy, agriculture, water resources, public health, and disaster management, and aims to exploit existing synergies and intersecting themes in order to enable better informed policy-making.

v) **Climate Change Mitigation** refers to organised processes whereby society seeks to reduce the pace and scale of climate change by reducing emissions of Carbon and other greenhouse gases and increasing the sequestration of atmospheric Carbon through absorption by vegetation or other forms of carbon sinks.

vi) **Adaptive Capacity**; refers to the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

vii) **Climate Change Sensitivity;** refers to the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli.

viii) **Climate Change Vulnerability;** refers to **t**he degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

ix) **Resilience can be defined as:** The ability of a community to resist, absorb, and recover from the effects of hazards in a timely and efficient manner, preserving or restoring its essential basic structures, functions and identity.

x) **An adaptation assessment** is defined by the IPCC as "the practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility" (IPCC, 2007

ANNEX VI: ANNEX VI: COMPREHENSIVE FRAMEWORK FOR MAINSTREAMING CCMA

Source: (UNDP 2010)

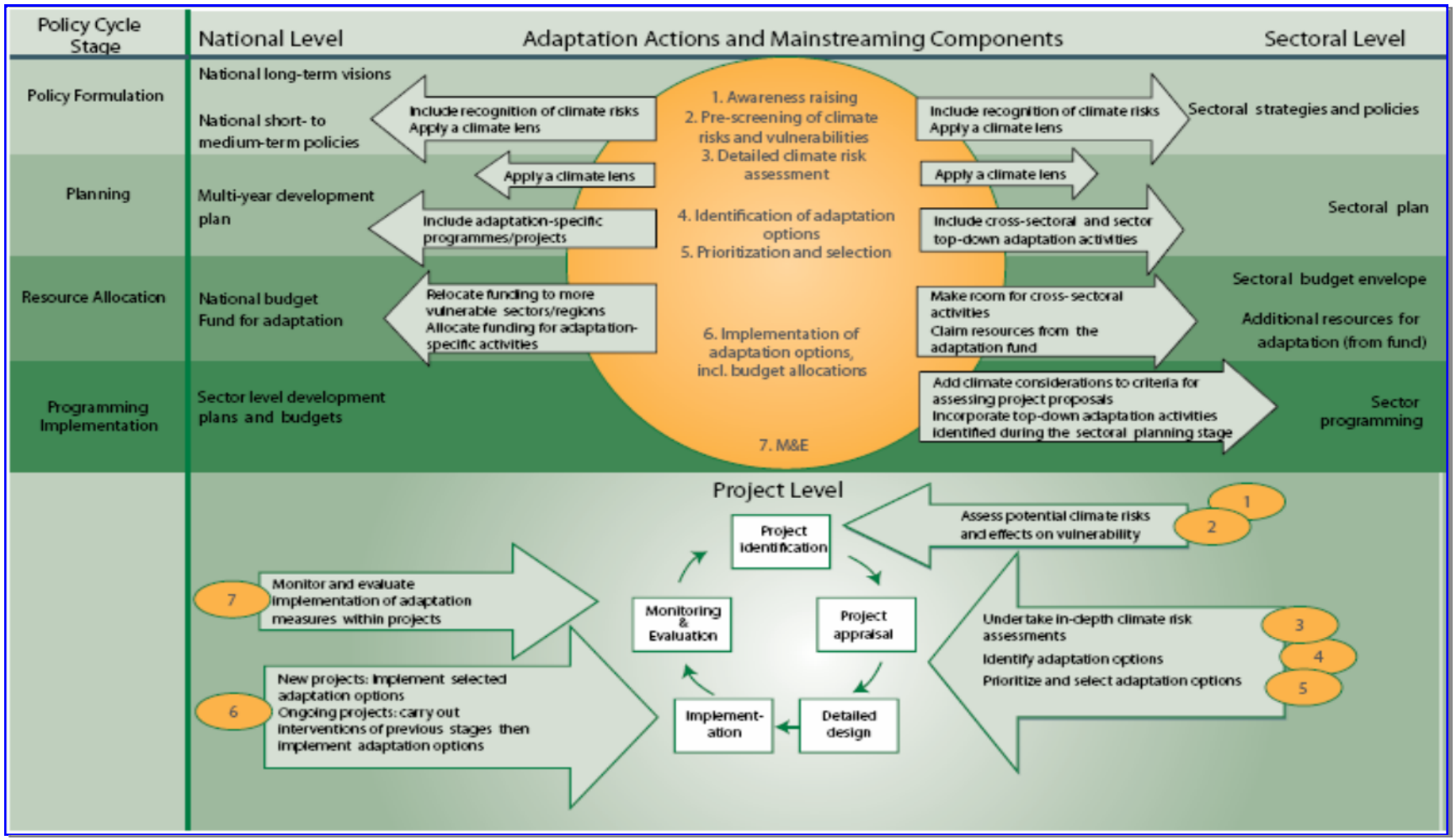


Figure 19: Comprehensive Framework for Mainstreaming Climate Change