NATIONAL CLIMATE CHANGE ACTION PLAN

REPUBLIC OF KENYA

Long-term National Low-carbon Climate Resilient Development Pathway

Climate Risk Assessment of Kenya's Flagship Projects

Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices

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Climate Risk Assessment:

Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices

To achieve its long-term vision of a globally competitive and increasingly prosperous Kenya, the Government of Kenya has developed Vision 2030 and identified over 100 flagship projects to be implemented during its First Medium Term Plan (2008 to 2012). A detailed review of the vulnerability of five of these flagship projects to climate change was undertaken in 2012 to inform development of Kenya's National Climate Change Action Plan and support integration of risk reduction strategies in Kenya's Second Medium Term Plan (2013 to 2017). The review was completed as part of Subcomponent 1, "Long-term National Low Carbon Climate Resilient Development Pathway," of the action plan process.

This brief presents outcomes of the review of one of these flagship projects, the "Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices," and the key climate risks and possible risk reduction strategies identified. It contains:

- Overview of the methodology used to identify potential climate risks and risk reduction options
- Summary of the outcomes of the risk assessment
- Detailed presentation of the risk assessment process and outcomes

Overview of Methodology

To conduct this assessment, a tailored Climate Risk Assessment methodology[1] was developed through an iterative process. This methodology was composed of two modules:

Module 1: Deconstructed climate risk assessment

To gain a better understanding of the climate change vulnerability of the selected project, the potential implications of specific climatic changes on its planned activities was assessed. Potential climate risks (e.g. higher temperatures, more frequent heavy rainfall events) to the project were deconstructed in relation to its different sub-components. The potential direct impacts of these changes were listed and quantitatively assessed with regard to (1) their likelihood of occurrence out to 2050 and (2) their potential severity or consequence. Combining the likelihood and consequence scores allowed for identification of the climatic changes likely to pose the greatest risk to the project's successful implementation and for its beneficiaries.

Module 2: Identification and assessment of illustrative resilience building and risk reduction options

Illustrative options for reducing the vulnerability of the flagship project to the listed high risk climatic changes were identified. Structural (or hardware) options, non-structural (or software) options and

[1] A full description of this methodology is provided in "Kenya's Climate Change Action Plan - Subcomponent 1: Long-term National Low-carbon Climate Resilient Development Pathway. Climate Risk Assessment of Kenya's Flagship Project." October 2012. The report is available at: http://www.kccap.info.

policy options were identified for each risk. To provide guidance regarding how to prioritize amongst the myriad of potential vulnerability reduction actions identified, these illustrative options in turn are assessed with respect to their:

- Feasibility of implementation and
- Potential to contribute to Kenya's sustainable development.

The outcome of this process was a shortlist of examples of potential strategies that could be used to reduce the vulnerability of the "Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices" to the impacts of climate change. More information on the methodology used is provided in the annex of this brief. The full report from the assessment of vulnerability of Kenya's flagship projects to the impacts of climate change may be found at: http://www.kccap.info.

Summary of Results: "Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices"

<table>
<tr><th colspan="4">About the project</th></tr>
<tr><td>Goals and objectives</td><td colspan="3">The flagship project seeks to improve living conditions for the poor by formalizing some slums and informal settlements, constructing permanent housing and improving physical infrastructure. Efforts by the Ministry of Housing towards this goal include:
• Delivery of the Kenya Slum Upgrading Programme, which includes the building and upgrading of housing infrastructure and the formation of housing cooperatives
• Construction of low mortgage flats by the National Housing Corporation
• Increasing the number of paved all-weather roads
• Design and construction of water and sewer lines</td></tr>
<tr><td>Progress to date</td><td colspan="3">Completed the construction of 600 housing units in the Kibera-Lang'ata Decanting site; construction of 450 housing units (about 67 percent of target) in Mavoko; formation of 14 housing cooperatives in Kisumu, Mombasa, Nairobi and Mavoko; construction of roads of various lengths (no greater than 4.5 kilometers) in the slums of Kibera and Lang'ata; and construction of water and sewer lines in Kiandutu, Mavoko and Thika, and in Langas in Eldoret.</td></tr>
<tr><th colspan="4">Climate risks of greatest concern due to their potential likelihood and severity/consequence</th></tr>
<tr><td rowspan="3">Climate Risk</td><td>More frequent drought</td><td>• Less water available to maintain sewage systems and ensure adequate provision of water to households
• Potential for people to switch to unsafe water sources, increasing the risk of disease</td><td rowspan="3">Potential Impacts</td></tr>
<tr><td>Unpredictable rainfall patterns during both the short and long rains</td><td>• Water management and planning (for housing and sewage systems) could become more challenging</td></tr>
<tr><td>Flooding, flash floods or flooding during seasonal periods</td><td>• Greater potential for loss of life and displacement of people
• Potential damage to road infrastructure, making access to slums and informal settlements more challenging
• Greater risk of water borne diseases due to contamination</td></tr>
</table>

	Increase in average annual temperature, and peaks of high temperatures	• Potential for increased damage to roads • Increased demand for water during high temperature periods, with implications for water supply and sewage systems	
Illustrative vulnerability reduction options assessed to be most feasibility and have the greatest potential to contribute to Kenya's sustainable development			
Vulnerable Project Components	Housing	• Update building codes to promote more efficient use of water • Build rainwater catchment infrastructure, particularly upstream dams that can act store water for the dry seasons, and within the targeted slum areas.	Vulnerability Reduction Options
	Road building	• Adjust construction requirements to ensure that roads are better able to withstand future climate hazards, particularly heavy rainfall events, and contract builders to repair road networks quickly over time. • Ensure there is emergency access routes or plans for all urban areas	
	Sewage and water provision	• Design in flood risks and resilience to water and sewerage provision systems	

Detailed Project Description and Risk Assessment Results:

1. Project Description

<table>
<tr><td rowspan="7">Overview of project goals and components</td><td colspan="3">Vision: To increase power generation in Kenya by up to 23,000 Megawatts (MW) in order to stimulate the economy. The electricity generated will be distributed at competitive prices to provide large sections of the population with access to energy.
MTP1 Target: To improve on power availability to meet industrial and domestic demand.</td></tr>
<tr><td rowspan="5">Project Components</td><td>Geothermal</td><td>Olkaria 1 (140 MW geothermal power project); Olkaria II(35 MW third unit); Olkaria III (additional 85 MW); Olkaria IV (140 MW geothermal power plan); Menengai (1000 MW geothermal project, installation of well head units; and construction of 140 MW power plant); Eburu (2.3 MW)</td></tr>
<tr><td>Wind</td><td>Ngong Wind Plant (5 MW); Lake Turkana Wind Power Station (300 MW); Ngong I Wind Phase II (6.8 MW): Ngong II Wind (13.6 MW)</td></tr>
<tr><td>Hydropower</td><td>Tana hydropower station (upgrade by 10 MW to 20 MW); Sangoro hydropower station (12 MW); Kiambere Unit 1 upgrade (from 72 to 82 MW); Kindaruma Unit 3 (build third 32 MW unit and rehabilitation)</td></tr>
<tr><td>Coal</td><td>Dongo Kundu Coal fired plant (600 MW); Athi River Mining Coal Power Station (19 MW)</td></tr>
<tr><td colspan="2">Rural Electrification Programme</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Location(s)</td><td colspan="3">Nationwide</td></tr>
<tr><td>Status</td><td colspan="3">Key project progress as reported by the Government of Kenya as of October 2012:
• 35 MW Olkaria II geothermal power plant completed on schedule in June 2010
• Work on the Menengai 1,000 MW Geothermal Project ongoing. Six wells were done, one well was tested and proved potential was found to be 10 MW
• Completion and operationalization of the 5 MW Ngong Wind Plant in December 2009
• Upgrading of Kiambere Unit 1 from 72 MW to 82 MW completed and operational from October 2009
• Commencement and testing of 20 MW Tana Power Station completed in November 2010
• Lake Turkana solar energy generation began in June 2012. The project is expected to generate 300 MW for the national grid when completed by June 2015
• The Kenya Power and Lighting Company is undertaking a US$240 million project in Nairobi for underground cabling
• The rural electrification distribution programme had connected over 800,000 of the targeted 1 million new users by May 2012</td></tr>
</table>

Expected Benefits	• Increased electric power production to fuel economic growth and thus contribute to poverty alleviation • Enhancement of environmental integrity (e.g., the provision of clean and modern power will lead to reduced logging for firewood and charcoal) • Access to clean and modern power will also bring health and other social benefits (e.g., reduced indoor pollution from wood-fired stoves and kerosene lamps will lower respiratory diseases and reduce the amount of time spent in fetching firewood, thus creating time for more productive activities and improved school attendance by girls)

2. General Description of Project Context and Rationale

Access to affordable, modern and clean energy in all sectors is crucial if Kenya is to achieve its development goals, but is particularly required by the household, manufacturing and service sectors. With respect to total final energy consumption at present, petroleum fuel accounts for about 28.57 percent, the bulk of which is consumed in the transport, manufacturing and commercial sectors, while electricity accounts for about 3.11 percent. The majority of total final energy consumed (67.65 percent) is derived from solid fuels—generally coal, charcoal, wood, straw, shrubs and agricultural crops. An estimated 84 percent of Kenyan households use solid fuels for cooking. Although wood is widely used in rural areas for cooking (83 percent of rural households), urban households rely mainly on charcoal (41 percent), kerosene (27 percent) and liquid petroleum gas or natural gas (22 percent). In addition, 6.1 percent of urban households use wood and 1.6 percent use electricity for cooking (KIPPRA, 2010).

Electricity, by virtue of its versatility in application, is crucial for economic growth. Kenya's electricity supply largely depends on hydro sources, which account for nearly half (47.8 percent) of the total installed capacity (1593 MW). Electricity is also generated from geothermal sources (12.4 percent), biomass cogeneration (2.4 percent) and wind (0.3 percent). The remaining 37 percent is from petroleum based thermal generation (GOK, 2012).[2] The dependency of Kenya's electricity sub-sector on hydro-generation enhances its sensitivity to climate risks, such as periods of low and excessive rainfall that main led to drought and flood events. Drought-induced reductions in hydropower generation have become a persistent feature of East Africa's power sector (Karekezi et al., 2009), with adverse impacts on economies in the region. During the 1999-2000 drought in Kenya, for example, extended power cuts due to low reservoir levels resulted in an estimated decline in national GDP of 1.45 percent (or an economic loss of about USD 442 million) (Karekezi et al., 2009). Unreliability within the electricity sub-sector[3] is one of the reasons behind the high penetration rate of costlier standby generation capacity (estimated at about 22 percent in the manufacturing sector, 31 percent in the furniture related enterprises, and even higher in agro industry, construction related industries, machinery, metals and chemical plants) (KIPPRA, 2010).

[2] Note that these percentages are seasonal. For example, the percentage contribution of hydro power decreases during drought periods when more of emergency thermal units are commissioned to meet the gap created by this fall in hydroelectric generation.

[3] The current frequency of power outages in Kenya is high (at 33 percent), which is 32 percent higher than Kenya's global competitors (GOK, 2007).

Vision 2030's planned energy projects are meant to cushion Kenya against the unreliability of its current reliance on hydro-generated electric power. A description of these projects is provided below:

- **Geothermal energy.** According to the Least Cost Power Development Plan (LCPDP) 2011-2031 (GOK, 2011), exploitation of Kenya's abundant geothermal resources (estimated to be 7000 MW) is a high potential option for Kenya. Geothermal energy's advantages over other power sources include financial analysis that identifies it as being the least cost option compared to other resource-based electricity generation options, its high capacity utilisation factor (above 92 percent), and its immunity to climatic factors and global energy geopolitics. Kenya plans to generate 1000 MW of energy from geothermal plants by 2014, and 5530 MW by 2030. To actualise this plan, the Government has set up the Geothermal Development Company to lead development of geothermal resources. Members of the private sector are also main players in this ambitious plan.
- **Wind energy.** Huge potential for wind electricity generation exists in Kenya—as high as 346 Watts per square meter and speeds of over 6 meters per second in parts of Marsabit, Kajiado, Laikipia, Meru, Nyandarua, Kilifi, Lamu, Isiolo Turkana, Samburu, Uasin Gishu Narok, and Kiambu counties, among others (GOK, 2012). The current installed capacity is 5.45 MW, with an additional 20 MW expected to be commissioned by the end of 2012. Other committed projects include the 300 MW Lake Turkana wind farm, the largest registered CDM project in Kenya so far, as well as the Ngong and Kinangop wind projects, both totalling to 110 MW (GOK, 2012). Projected short term (by 2014) generation is about 435.5 MW, implying that the Vision 2030 goal for wind power generation is on course.
- **Hydropower.** The combined installed capacity of Kenya's hydropower plants is 766.88 MW (KenGen, n.d.). Much of this production is from the country's old large scale hydropower plants (such as the Seven Folks Dams) and new large scale projects (such as Turkwel, completed in 1991, with a capacity of 106 MW, and Sondu Miriu, completed in 2004, with a capacity of 60 MW). The rest of the hydro generation capacity is met by small and mini hydropower stations such as the Tana (20 MW), Sagana, Mesco and Ndula stations. In recent years, the focus has shifted to small and mini hydropower stations due to sensitivity of the large scale projects to climate variability and environmental impacts. The potential for small hydropower generation in Kenya is estimated at 3,000 MW, of which it is estimated that less than 30 MW have been exploited and only 15 MW supply the grid (GOK, 2011). Much of this potential lies in the Highlands with its undulating topography and abundant rainfall.
- **Biomass energy.** Biomass provides the largest proportion (about 68 percent) of Kenya's total energy demand (KIPPRA, 2010) and is expected to continue to be an important source of energy in the foreseeable future. The government's biomass energy policy is two pronged: increasing the country's biomass generation capacity to bridge the widening gap between fuelwood demand and supply, and expanding co-generation with the use of forestry and agro-industry residues, including sugarcane bagasse (GOK, 2012). The total potential for cogeneration using sugarcane bagasse is estimated to be 193 MW (GOK, 2011). Biomass resource in some regions in Kenya have been depleted by over-exploitation and climate variability (e.g., reduced rainfall) (Walubengo, n.d.).
- **Solar energy.** Solar electrification, particularly off-grid solar home systems (averaging less than 50 Watt peak) have also played and continue to play a major role in electrification in the

country. Off-grid solar home systems are particularly suitable for sparsely located settlements (such as the situation in Kenya) where grid connection is both economically and technically challenging.

- **Increasing Connectivity.** The Government of Kenya is seeking to have 100 percent connectivity across the country through grid extensions and off-grid systems (GOK, 2009). The on-going Energy Access Scale-Up programme, through which a million households will be connected with power by 2014 (increasing connectivity from the current 22 percent to 30 percent), is the beginning of this ambitious programme. Institutions established to help achieve this goal include the Rural Electrification Authority, Kenya Power and the newly created Kenya Electricity Transmission Company Ltd. The latter is to build, operate and maintain new electricity transmission lines and associated substations that will form the backbone of the National Transmission Grid. One measure for climate proofing electric power distribution systems is under-ground cabling. Kenya Power is undertaking such a project in Nairobi at a cost of US$240 million (GOK, n.d.).

3. Climate Context

A. Historic/current climate

- The three climate elements with potential impact on the country's future energy systems are rainfall, temperature and wind.
- Repeated and intensifying droughts have often caused a reduction in the country's hydropower generation, with negative repercussions, particularly for the manufacturing sector.
- The grid electricity system is presently affected by extreme rainfall/storm events combined with floods which in some instances can damage power networks. Frequent power outages during heavy rains have been attributed to a weak/aging transmission and distribution network (GOK, 2011).

B. Projected climatic changes

- Most models suggest that average annual rainfall will increase but vary with respect to anticipated changes in regional and seasonal rainfall patterns. Most climate projections predict increase in severity and intensity of some of the changes currently being observed.
- Biomass energy production will likely be affected by a combination of higher temperatures, intensifying droughts and water scarcity. These changes could lead to a gradual drying up of biomass in some regions in Kenya. The western and coastal parts of the country, which are the country's sugarcane belts and have the potential for bagasse based cogeneration, are projected to experience more rainfall. Declines in mean annual rainfall projected to occur in other areas of Kenya should be taken into consideration when determining the location of future major biomass energy projects, particularly cogeneration projects. Climate information will also be critical in determining which tree species to grow in different locations as Kenya attempts to bridge its gap between fuelwood demand and supply.
- As Kenya's electricity sub-sector becomes increasingly dominated by geothermal energy, its degree of vulnerability to climate change could decline. Nevertheless, it would be prudent to

undertake a climate risk assessment of specific projects to understand their vulnerability to future climate changes and inform measures that could be taken to reduce the vulnerability.[4]

- Wind power is potentially sensitive to future climate change (Pereira de Lucena et al., 2010). The next few decades may see greater variation in seasonal and annual wind speeds, making long-term planning for wind energy purposes problematic (Freedman, Waight & Duffy, n.d.). In scientific circles, the general assumption is the reduction in temperature difference, or gradient, between the poles and the equator resulting from climate change will reduce mid-latitude winds. However, the issue is quite complex and there are many unknowns. Currently, there is no literature on the potential impacts of climate variability and change on wind power production in Kenya or the region more generally. This research gap might need to be filled given that wind power is expected to constitute a significant percentage of Kenya's future electricity sub-sector.
- Solar photovoltaic electrification could potentially experience reduced performance (reduced output) with rising temperatures (Solar Thermal Magazine, n.d.).

4. Climate Risk Assessment

To gain an understanding of the potential vulnerability of the "Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices" to projected climate change, a general climate risk assessment was completed. Drawing upon existing literature, potential changes in climatic conditions in location where the flagship project is being implemented were identified. The potential *direct* impact of these changes was then identified. Each of these potential impacts was then quantitatively assessed on a scale of 1 to 5 with respect to their likelihood of occurrence per year in the 2050s and their potential severity to generate an overall climate risk assessment score. Climate risks with high scores were flagged for further analysis.

Sub Sector	Key Climate Risks	Potential Direct Impacts	Future Likelihood (1-5)[5]	Potential Future Severity / Consequence (1-5)[6]	Overall Risk Assessment (Low/Moderate/High)	Flagged for Deeper Assessment
Climate proofing and rehabilitating	Increase in average annual temperature	Higher evapotranspiration of on water bodies	5	2	Moderate	

[4] Such an assessment has been done through the Africa Adaptation Programme for the Sondu Miriu power plant using the community-level risk screening tool, CRiSTAL (Climate Risk Screening Tool – Adaptation and Livelihoods). The tool was used to integrate risk reduction and climate change adaptation into this community-level project. The assessment determined that while the need to expand electricity production on River Sondu is sound, the threats and projected impacts of climate change requires careful planning, especially when viewed with associated socio-cultural impacts. Although General Circulation Models project an increase in rainfall in the Western parts of Kenya, which then may translate into increased water flow along the Sondu River, other non-climate related factors also need to be considered as proper management of water catchment areas, land tenure and land-use and land degradation (including soil erosion) will influence water flow in the tributaries that feed the Sondu River.

[5] Likelihood: 1 = Rare – Event not expected to occur, but possible (<5 percent probability of occurrence per year in 2050s); 2 = Unlikely – Event unlikely to occur, but not negligible (5-33 percent probability of occurrence per year in 2050s); 3 = Possible – Event less likely than not, but still appreciable change of occurring (33 – 66 percent probability of occurrence per year in 2050s); 4 = Likely – Event more likely to occur than not (66 – 95 percent probability of occurrence per year in 2050s); 5 = Almost certain –Event highly likely to occur (>95 percent probability of occurrence per year in 2050s)

[6] Consequence: 1 = insignificant; 2 = minor; 3 = reasonable/moderate; 4 = major; 5 = severe

large scale hydro schemes	Decrease in mean annual precipitation	Less water available for power generation, particularly in dry season	4	4	High	
	Unpredictable precipitation during both the short and long rains	Demand and supply challenges from hydro sources	4	3	Moderate	
	More frequent drought	Critical and extended water availability challenges leading to decrease in generation	4	5	High	✓
	Flooding	Damage to infrastructure and siltation	4	4	High	
	More frequent heavy rainfall events	Flooding	4	3	Moderate	
		Damage to infrastructure and flooding downstream	4	3	Moderate	
Development and climate proofing small scale hydro schemes	Increase in average annual temperature	Higher evapotranspiration of on water bodies	4	2	Moderate	
	Decrease in mean annual precipitation	Less water available for power generation, particularly in the dry season	4	5	High	✓
	Unpredictable rainfall during both the short and long rains	Demand and supply challenges from hydro sources	4	4	High	✓
	More frequent drought	Critical and extended water availability challenges leading to decrease in generation	4	5	High	✓
	Changes in the timing of the short and long rains	Damage to infrastructure and siltation	4	3	Moderate	
	Flooding events	Increased flooding upstream of dam infrastructure	4	4	High	
		Failure of dam infrastructure leading to downstream flash flooding	4	3	Moderate	
Wind	Changing wind regimes	Decrease in generation capacity	2	3	Moderate	
Biomass power	Increase in average annual temperature	Biomass supply challenges	5	2	Moderate	

generation schemes	Decrease in mean annual precipitation	Biomass supply challenges	3	2	Moderate	
	Unpredictable precipitation during both the short and long rains	Biomass supply challenges	4	2	Moderate	
	More frequent drought	Biomass supply challenges	4	5	High	✓
	Changes in the timing of the short and long rains	Biomass supply challenges	4	2	Moderate	
	Flooding events	Biomass supply challenges	4	4	High	
Transmission and distribution	Flooding	Failure in supply system	4	4	High	
	Extreme storms and rains	Failure in supply system	3	4	Moderate	

5. Options for Reducing Selected Risks

In the next phase of the climate risk assessment process, possible measures for reducing the vulnerability of the "Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices" to the high ranking climate risks were identified. For each risk, illustrative options were identified that fit within the following categories:

- Structural options – defined as physical or landscape level interventions that serve to modify or prevent the threat, or that involve a change in use or change in location;
- Non-structural options – defined as interventions that build human capacity through actions such as research, education, institutional strengthening and social change; or
- Policy options – defined as the introduction or modification of existing government policies, strategies and/or measures.

The possible benefits of these intervention options were noted. The resulting list presented in the table below is not exhaustive; a range of other vulnerability reduction options could be considered.

Sub component	Key Climate Risk	Potential Direct Impacts	Intervention Description	Expected Key Impacts of Intervention Option
Climate proofing and rehabilitating large scale hydro schemes	More frequent drought	Critical and extended water availability challenges leading to decrease in generation	**Structural:**	
			Establish forest cover targets in critical water catchment areas, and provide the financing and capacity required to ensure achievement of these targets.	Improved water resource availability
			Expand ambition for energy generation from wind, solar, geothermal and biomass power generation, and increasing the level of feed in tariff for renewable generation to draw in private sector operators.	Improved system resilience to extended drought and other shocks
			Non-structural	
			Develop demand management plans and use incentives and instruments to level peak demand/spread demand over time.	Reduce impact of drought and strategic use of constrained power generation
			Policy:	
			Regulatory: Set specific quantitative and	Improved system

Sub component	Key Climate Risk	Potential Direct Impacts	Intervention Description	Expected Key Impacts of Intervention Option
			temporal targets for a diversified renewable energy mix that is resilient and can provide base/peak load during prolonged periods of drought and hydro power suppression or absence	resilience to extended drought and other shocks
			Regulatory: Innovative demand smoothing measures and instruments, such as time of use pricing/incentives.	Smooth electricity demand
Development and climate proofing of small scale hydro schemes	Decrease in mean annual rainfall	Less water available for power generation, particularly in dry season	**Structural:**	
			Effective local watershed protection and management that monitors, rewards and enforces where necessary tree cover for the river banks and water catchments.	Improved water resource availability
			Expand of grid connection to un-connected small hydro sites as back up.	Resilient electricity delivery
			Non-structural:	
			Local participatory planning for conservation of watersheds	Improved water resources and but in from local communities
			Policy:	
			Regulatory: procedural standards for vulnerability studies for all small scale hydro installations.	Reduce impact of drought and strategic use of constrained power generation
	Unpredictable rainfall during both the short and long rains	Demand and supply challenges from hydro sources	**Structural:**	
			Maintenance schedule and plans for effective and efficient operation of systems	Reduce costs and loss of power production opportunities
			Non-structural:	
			Provision of localised information of expected rains and water flows on electricity generating waterways	Mitigate the loss of power production opportunities
			Policy	
			Regulatory: Mandate that small scale hydro generation should have accompanying watershed management strategy and grid connection to feed-in and feed-off where relevant	More water resources available for power generation
	More frequent drought	Critical and extended water availability challenges leading to decrease in generation	**Structural:**	
			Alternative or back up generation systems, or grid connection where cost effective, to ensure continuity of supply during prolonged dry periods	Increased system resilience
			Non structural:	
			Provide information to local communities on the potential supply disruptions caused by drought	Reduce impact of drought by enabling timely and effective management
			Policy:	
			Regulatory: Procedural standards for vulnerability studies and drought management	Reduce demand during critical periods
Biomass power generation schemes	More frequent drought	Biomass supply challenges	**Non structural:**	
			Inform utilities, business and local communities of drought predictions and implication for power supply to enable effective and timely response strategies	Reduce impact of drought by enabling timely and effective management

Sub component	Key Climate Risk	Potential Direct Impacts	Intervention Description	Expected Key Impacts of Intervention Option
			Policy:	
			Regulatory: Set specific quantitative and temporal targets for a diversified renewable energy mix that is resilient and can provide base/peak load during prolonged periods of drought and hydro power suppression or absence	Improved system resilience to extended drought and other shocks

6. Outcomes of the Analysis

Using expert judgement, each of the illustrative vulnerability reduction options identified were then assessed on a quantitative basis in terms of their:

- Potential feasibility, taking into consideration factors such as consistency with existing risk management activities, potential negative spin-offs, and attractiveness to donors and partners
- Potential contribution to Kenya's sustainable development, looking at factors such as employment generation potential, establishment of (grey and green) infrastructure, possible number of direct beneficiaries, and advancement of equity.

By combining the scores from this assessment, an overall assessment of an option's potential value as a risk reduction strategy was identified. Options receiving the highest scores (as indicated by check marks in the table below) were judged to be worth considering as possible ways in which to reduce the vulnerability of the "Installation of Physical and Social Infrastructure in Slums in 20 Urban Areas" flagship project to the impacts of climate change.

Sub component	Key Climate Risk	Potential Direct Impacts	Intervention Description	Feasibility Subtotal	Sustainable Development Subtotal	Outcome score	Priority Options
Climate proofing and rehabilitating large scale hydro schemes	More frequent drought	Critical and extended water availability challenges leading to decrease in generation	**Structural:**				
			Establish forest cover targets in critical water catchment areas, and provide the financing and capacity required to ensure achievement of these targets.	10	16	88%	✓
			Expand ambition for energy generation from wind, solar, geothermal and biomass power generation, and increasing the level of feed in tariff for renewable generation to draw in private sector operators.	9	19	90%	✓
			Non-structural				
			Develop demand management plans and use incentives and instruments to level peak demand/spread demand over time.	10	7	67%	

Sub component	Key Climate Risk	Potential Direct Impacts	Intervention Description	Feasibility Subtotal	Sustainable Development Subtotal	Outcome score	Priority Options
			Policy:				
			Regulatory: Set specific quantitative and temporal targets for a diversified renewable energy mix that is resilient and can provide base/peak load during prolonged periods of drought and hydro power suppression or absence	9	20	93%	✓
			Regulatory: Innovative demand smoothing measures and instruments, such as time of use pricing/incentives.	10	14	83%	
Development and climate proofing of small scale hydro schemes	Decrease in mean annual rainfall	Less water available for power generation, particularly in dry season	**Structural:**				
			Effective local watershed protection and management that monitors, rewards and enforces where necessary tree cover for the river banks and water catchments.	9	18	88%	✓
			Expand of grid connection to un-connected small hydro sites as back up.	10	17	90%	✓
			Non-structural:				
			Local participatory planning for conservation of watersheds	8	14	73%	
			Policy:				
			Regulatory: procedural standards for vulnerability studies for all small scale hydro installations.	9	7	62%	
	Unpredictable rainfall during both the short and long rains	Demand and supply challenges from hydro sources	**Structural:**				
			Maintenance schedule and plans for effective and efficient operation of systems	10	6	64%	
			Non-structural:				
			Provision of localised information of expected rains and water flows on electricity generating waterways	10	14	83%	
			Policy				
			Regulatory: Mandate that small scale hydro generation should have accompanying watershed management strategy and grid connection to feed-in and feed-off where relevant	8	18	83%	
	More frequent drought	Critical and extended water availability challenges	**Structural:**				
			Alternative or back up generation systems, or grid connection where cost effective, to ensure	10	11	76%	

Sub component	Key Climate Risk	Potential Direct Impacts	Intervention Description	Feasibility Subtotal	Sustainable Development Subtotal	Outcome score	Priority Options
		leading to decrease in generation	continuity of supply during prolonged dry periods				
			Non structural:				
			Provide information to local communities on the potential supply disruptions caused by drought	9	9	66%	
			Policy:				
			Regulatory: Procedural standards for vulnerability studies and drought management	10	8	69%	
Biomass power generation schemes	More frequent drought	Biomass supply challenges	**Non structural:**				
			Inform utilities, business and local communities of drought predictions and implication for power supply to enable effective and timely response strategies	9	10	69%	
			Policy:				
			Regulatory: Set specific quantitative and temporal targets for a diversified renewable energy mix that is resilient and can provide base/peak load during prolonged periods of drought and hydro power suppression or absence	9	20	93%	✓

References

Government of the Republic of Kenya, Ministry of Energy (GOK). 2011. *Least Cost Power Development Plan (LCPDP) 2011-2031*. Retrieved from http://www.erc.go.ke/erc/LCPDP.pdf

Freedman, J.M., Waight, K.T. & Duffy, P. no date*. Does climate change threaten wind resources?* Retrieved from www.nawindpower.com

Government of Kenya. no date. *Energy generation of 23,000 MW and distribution*. Kenya Vision 2030 web site. Retrieved from http://www.vision2030.go.ke/index.php/projects/details/Macro_enablers/2

Government of Kenya. 2007. *Kenya Vision 2030: A globally competitive and prosperous Kenya*. Retrieved from http://www.kilimo.go.ke/kilimo_docs/pdf/Kenya_VISION_2030-final.pdf

Government of Kenya. 2009. *Rural Electrification Master Plan.*

Government of Kenya. 2011. *Scaling Up Renewable Energy Programme (SREP): Investment Plan for Kenya*. Draft of May 2011.

Government of the Republic of Kenya. 2012. National Energy Policy, Draft of May 2012

Karekezi, S. et al. 2009. *Large Scale Hydropower, Renewable Energy Adaptation and Climate Change: Climate change and energy security in East and Horn of Africa*. AFREPREN/FWD.

Kenya Electricity Generating Company (KenGen). No date. *Hydro power stations*. Retrieved from http://www.kengen.co.ke/index.php?page=business&subpage=hydro

Kenya Institute for Public Policy Research and Analysis (KIPPRA). 2010. *A comprehensive study and analysis on energy consumption patterns in Kenya*. A report for the Energy Regulatory Commission.

Pereira de Lucena et al. 2010. The vulnerability of wind power to climate change in Brazil. *Renewable Energy* 35(5): 904–912.

Solar Thermal Magazine. no date. *University study confirms solar PV efficiencies decline with rising outside temperatures.* Retrieved from http://www.solarthermalmagazine.com/?p=2394

Walubengo, D. no date. *Community-led action to use forestry in building resilience to climate change: A Kenyan case study (Njoro Division, Nakuru District, Kenya)*. London: International Institute for Environment and Development.

Annex: Detailed Methodology

The climate risk assessment of Kenya's flagship projects was undertaken by completing the following steps:

1. Identification of Vulnerable Flagship Projects

The first step in the risk assessment process was to determine which, if any, of Kenya's flagship projects are particularly vulnerable to the impacts of climate change. A list of 71 flagship projects identified for execution within Kenya's first Medium Term Plan was therefore complied, drawing upon information provided by the Ministry of State for Planning, National Development and Vision 2030. Basic information about the objectives and accomplishments to date of each of these flagship projects was obtained by reviewing the Kenya Vision 2030 web page (http://www.vision2030.go.ke/index.php).

An initial screening of each of these flagship projects was then completing using a draft climate risk screening tool developed by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The draft GIZ screening tool assesses a project's vulnerability to climate change against the following four questions:

1. Is the project active in one of the following sectors: agriculture and rural development; forests/forestry; natural resources management and biodiversity; water; disaster management; urban, municipal or regional development; health; or energy? (Yes or No)
2. Is the project situation in one of following geographic regions: coastal zones; floodplains; areas affected by hurricanes or typhoons; arid areas; or mountain regions? (Yes or No)
3. Does the impact of the project depend on important climate parameters such as temperature, precipitation or wind? (Yes or No)
4. Does the project provide opportunities to significantly increase the adaptive capacity of the target group(s) or ecosystem(s)? (Yes or No)

If the response to any one of the above questions was "yes," the flagship project was tagged for further assessment. A total of 41 projects were thereby tagged for further examination. To further refine this list, a secondary screening was applied. Specifically, projects were prioritized for deeper screening if, in the expert opinion of the evaluators:

- The activities to be undertaken as part of the flagship project are likely to be significantly affected by either current climate variability and/or long-term climate change; and
- Implementation of the project could be expected to increase Kenyans adaptive capacity.

Based on completion of this deeper screening process, 13 projects were identified as being particularly vulnerable to the impacts of climate change and having potential capacity to contribute to building adaptive capacity in Kenya.

2. Selection of Priority Projects for Detailed Analysis

Each of the 13 projects identified through the initial screening process could have been assessed for their vulnerability to the impacts of climate change and options for reducing this vulnerability.

However, in light of the scope and mandate of SC1, a further screen was applied in an effort to narrow down the list of particularly vulnerable projects to a maximum of five. To accomplish this goal, the identified projects were assessed with respect to their potential to provide benefits to a significant number of Kenyans. Each project was therefore screened against the following questions:

1. What is the expected number of direct beneficiaries of the flagship project? Responses to this question were ranked as follows:
    - Low if less than 500,000 Kenyans are expected to directly benefit from the project. (Allocated 1 point)
    - Moderate if 500,000 to 1 million Kenyans are expected to directly benefit from the project. (Allocated 2 points)
    - High if more than 1 million Kenyans are expected to directly benefit from the project. (Allocated 3 points)
2. Are the expected beneficiaries of the project members of vulnerable groups (e.g. women and children, indigenous peoples, pastoralists, individuals living in arid and semi-arid lands)? Responses to this question were ranked as follows:
    - If "no," then assigned zero points.
    - If "some," then assigned 1 point.
    - If the expected primary beneficiaries of the flagship project, then it was assigned 2 points.
3. Is the flagship project likely to be carried over into Kenya's second MTP? Responses to this question were ranked as follow:
    - If "no," then assigned zero points.
    - If "yes," then assigned 1 point.

Based on use of these assessment questions, projects that received a total number of points equal to or greater than 4 were identified as priority projects for deeper assessment. Seven priority projects were identified following application of this secondary screening process. From this list, the reviewers identified five priority projects for in-depth assessment, taking into consideration a desire to achieve a balance between "Economic," "Social" and "Enablers and Macro Projects," and to examine projects from different sectors and/or to be implemented in different regions of the country. Based on these considerations, the following five projects were selected:

- "ASAL Development Projects"
- "Setting up of Five Livestock Disease-free Zones in the ASAL Regions"
- "Installation of Physical and Social Infrastructure in Slums in 20 Urban Areas"
- "Rehabilitation and Protection of Indigenous Forests in Five Water Towers"
- "Energy Scale up Programme and Rural Electrification: Generation of 23,000 MW and Distributed at Competitive Prices."

3. Climate Risk Assessment

A general climate risk assessment was completed for each of the flagship projects by completing the following steps:

1. <u>Identification of potential changes in climatic conditions.</u> Drawing upon existing literature sources as well as draft reports produced as part of Sub-component 3 (SC3) of the Kenya

Climate Change Action Plan process (development of a National Adaptation Plan), potential changes in climatic conditions (or climate risk factors) were identified. These climate risks included: an increase mean annual temperatures; an increase in the frequency of drought conditions; more frequent heavy rainfall events; a decline in mean annual precipitation; and changes in the timing of the short and long rains.

2. Identification of how the anticipated change in climatic conditions might directly impact the flagship project. For example, the reviewers asked the question "how might a decline in mean annual precipitation directly impact the activities planned as part of the ASAL Development Projects?" Potential impacts were then listed in the appropriate table. In order to limit the scope of the analysis, care was taken during this process to explicitly focus on the direct impact of the anticipated climate risk on the flagship project. For example, a decline in mean annual precipitation was identified as having the potential to make less water available for irrigation. The potential secondary impacts of this anticipated direct impact, such as a decline in crop production, were not considered in the analysis.

3. Assessment of the likelihood of the anticipated direct impact occurring. Based on the background information gathered and expert judgement, the likelihood (or probability of occurrence) of an anticipated event taking place was assessed. For consistency, the likelihood scale used within the analysis was the same as applied in the draft documents prepared as part of SC3, namely:

    1 = Rare – Event not expected to occur, but possible (<5 percent probability of occurrence per year in 2050s);
    2 = Unlikely – Event unlikely to occur, but not negligible (5-33 percent probability of occurrence per year in 2050s);
    3 = Possible – Event less likely than not, but still appreciable chance of occurring (33 – 66 percent probability of occurrence per year in 2050s);
    4 = Likely – Event more likely to occur than not (66 – 95 percent probability of occurrence per year in 2050s); or
    5 = Almost certain –Event highly likely to occur (>95 percent probability of occurrence per year in 2050s).

4. Assessment of the consequence of the anticipated direct impact. For each of the anticipated direct impacts on the assessed flagship project, the potential outcome was assessed using expert judgement as to being either:

    1 = insignificant;
    2 = minor;
    3 = reasonable/moderate;
    4 = major; or
    5 = severe.

5. Overall climate risk assessment. The degree of vulnerability of the flagship project to the climate risk factors identified was determined by adding together the likelihood and consequence scores, for a potential scoring range of 2 to 10. Based on this analysis, the risk

posed by the projected change in climate for the examined flagship project was deemed to be:

- *Low,* if the total score was between 2 and 4;
- *Moderate,* if the total score was between 5 and 7; and
- *High,* if the total score was between 8 and 10.

Climate risk factors ranked as "high" were flagged for more detailed consideration with respect to how the flagship project's vulnerability to their projected occurrence might be reduced. Using the above steps, a number of high risk climate events are identified for each projects (and/or sub-component). When necessary, the number of priority climate risks flagged is limited to two risks per project sub-component and a total of six risks per flagship project.

4. Identification of Illustrative Options for Reducing Climate Risks

The next phase of the climate risk assessment process involved the identification of possible measures that could be taken to reduce the vulnerability of the individual flagship projects to the highest ranking climate risks. Illustrative examples of possible vulnerability reduction options were identified and assessed. In all cases, a wide range of additional risk reduction strategies could have been considered. The options identified therefore are not necessarily the best strategies available, or ones that might be considered for implementation by Kenya.

In seeking measures to reduce vulnerability to climate change, a wide variety of possible actions may be considered. Some of these actions may involve changes to natural or human-generated physical structures. Others might focus on building the human, social, financial and/or political capacity of individuals, communities and businesses to prepare for and respond to the impacts of climate change. Additional options may focus on government-led policy initiatives that serve to strengthen adaptive capacity. Based upon this understanding, options for reducing vulnerability to priority climate risks were identified that fit within each of the following categories:

- *Structural options* – defined as physical or landscape level interventions that serve to modify or prevent the threat, or that involve a change in use or change in location;
- *Non-structural options* – defined as interventions that build human capacity through actions such as research, education, institutional strengthening and social change; or
- *Policy options* – defined as the introduction or modification of existing government policies, strategies and/or measures. To further convey the types of policy instruments that could be used to reduce vulnerability to identified climate risks, drawing on UNEP (2011), potential options were identified as being either market-based, regulatory, public investment, information based, international cooperation, or institution based instruments.

To further define the identified climate risk management options, the expected key impact of the proposed intervention was named. In essence, this description outlines how the proposed risk management option is anticipated to reduce the flagship project's vulnerability to one of the key climate risks to which it is projected to be exposed.

The proposed options' characteristics with respect to two time bound measures were also described:

- When the identified option likely would need to be implemented given projected changes in Kenya's climate, with the parameters for consideration being either:
    - Immediately, defined as being during the next Medium Term Plan (2013 to 2016); or
    - Longer term, defined as needing to occur after 2016.
- The estimated length of time to implement the illustrative option, with the parameters for consideration being either:
    - A short amount of time, defined as the option potentially be implemented in less than 3 years;
    - A middle length of time, defined as the option potentially be implemented in 3 to 5 years; or
    - A long length of time, defined as the option potentially requiring more than 5 years to implement, and including those action that may be viewed as needing to take place indefinitely.

5. Assessment of Climate Risk Options

The selected, illustrative options were then assessed with respect to their suitability and viability from two different perspectives: the feasibility of their implementation and their potential contribution to Kenya's sustainable development. To assess the feasibility of the proposed option, a slightly modified version of the assessment criteria and indicators used within the climate risk screening tool ORCHID (Opportunities and Risks of Climate Change and Disasters) was applied (Tanner et al., 2007, p.118). Using this approach, each proposed option was assessed against the following five questions:

1. Does the proposed risk management option support win-win or no regrets actions by:
    - Increasing capacity to address current or future climate risks? If so, then 1 point scored.
    - Increasing capacity to address current and future climate risk? If so, then 2 points scored.
2. Is the proposed risk management option consistent with existing risk management activities?
    - If no, then 1 point scored.
    - If yes, then 2 points scored.
3. Can the cost effectiveness of the proposed risk management option be easily determined?
    - If no, then 1 point scored.
    - If yes, then 2 points scored.
4. Are their potential negative spin-off impacts associated with the proposed risk management option?
    - If a high likelihood for negative spin-off impacts exists, then 1 point scored.
    - If a low likelihood of negative spin-off impacts exists, then 2 points scored.
5. Is the proposed risk management option practical and feasible for a donor, partners and project implementer?
    - If no, which was defined as the option being impractical and not attractive to donors, then zero points scored.

- If difficult, defined as being practical (i.e. there is experience with its implementation and the cost is not exorbitant) but not attractive to donors, or not practical but potentially attractive to donors, then 1 point scored.
- If yes, defined as being practical and likely to be attractive to donors, then 2 points scored.

The points assigned in response to these questions were then totaled to determine the assessed feasibility of the examined climate risk management option. The total points earned ranged from four to 10.

In the second stage of this analysis, the potential contribution of the proposed climate risk management option to sustainable development was assessed using expert judgement. The following questions were used within this assessment:

1. Does the option promote employment opportunities?
2. Does the option promote access to appropriate information, skills/capacity, technology or practices?
3. Does the option build, or help to build, relevant (physical) infrastructure (green or grey) that facilitates the movement of goods, people and/or (ecosystem) services?
4. Does the option build, or remove barriers to, relevant policy/information infrastructure?
5. Does the option have the potential to promote equity (e.g., gender, age or socio-economic)?
6. What is the expected number of direct beneficiaries of the project?:
   - Low, defined as being less than 500,000 people? If yes, scored as 1 point.
   - Moderate, defined as being between 500,000 and 1 million people? If yes, scored as 2 points.
   - High, defined as more than 1 million people? If, yes, scored as 3 points.
7. Does the option have benefits for water quality, air quality and/or biodiversity?

With the exception of question 6, each of these questions was ranked against the following scale:

- If expected to have a negative impact, scored as -1 point.
- If expected to have a neutral impact, scored as zero points.
- If expected to have a low positive impact, scored as 1 point.
- If expected to have medium positive impact, scored as 2 points.
- If expected to have a high positive impact, scored as 3 points.

The scores for each question were then totaled to estimate to proposed risk management option's contribution to sustainable development (a range of -6 to 21 points).

The overall assessed feasibility and appropriateness of the proposed options was determined by averaging of the percentage scores received for the assessed feasibility of the option (that is, X out of a total possible score of 10, expressed as a percentage) and its potential contribution to Kenya's sustainable development (X out of a total possible score of 21, expressed as a percentage). The options which received the highest scores were judged as being worth being considered for implementation by the Government of Kenya as it strives to integrate climate change considerations into its next MTP.