# KENYA CLIMATE CHANGE BRIEFING

## Overview

Kenya has a tropical climate moderated by diverse topography in the west. The central highlands are substantially cooler than the coast and temperatures vary little throughout the year – dropping 2°C in the coolest seasons (June to September). Rainfall is driven by the migration of the Inter-Tropical Convergence Zone and occurs in two distinct wet periods – the 'short' rains (October to December) and the 'long' rains (March to May). During these seasons the rainfall received is generally 50 - 200 mm per month, exceeding 300 mm in some locations. The onset, duration and intensity vary considerably each year. Kenya is very sensitive to fluctuations in sea-surface temperatures in the tropical Atlantic and Indian Oceans, which in turn are loosely coupled to the El Niño Southern Oscillation; in El Niño years the 'short' rains are longer and there is flooding whilst in the alternate La Niña years the 'long' rains are drier and there may be droughts.

### Temperature

The mean temperature is predicted to increase in Kenya with a greater frequency of hot days and nights

### Rainfall

Rainfall is predicted to remain the same but shift in seasonality ('short' rains increase in duration, 'long' rains decrease) and increase in intensity

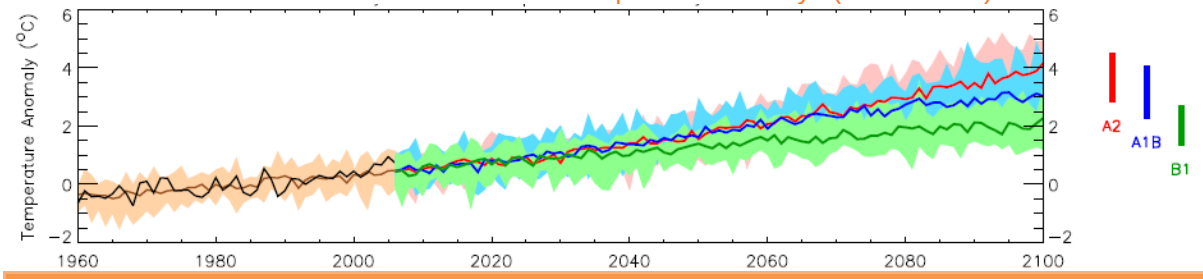
### Extreme Events

An increase is expected in the frequency and intensity of extreme events, primarily droughts and floods. Expect extreme events to occur in new locations.

## Climate Change

Observational evidence from all continents and most oceans show that many natural systems are being affected by climate change, particularly temperature increases. The mean temperature in Kenya has been steadily increasing since the 1960s (see the graph below), however minimum temperature shows the most rapid increase, reducing the diurnal[1] range; the exception is in areas near large water bodies (for example Lake Victoria) where minimum temperatures have remained constant and maximum temperatures have increased (increasing the diurnal range). In recent years, the season of the 'short' rains has extended while the 'long' rains have decreased in both duration and intensity (MENR, 2009). The graph below also summarises the mean temperatures predicted by 22 Global Climate Models (GCM). Their range is indicated by the shading and the lines refer to three emissions scenarios – A2 (high), A1B (medium) and B1 (low) (describing future global economic growth and energy usage). The GCMs predict by 2090 annual mean global temperatures will increase by 1.3 – 4.5°C (there has been no regional downscaling of the GCMs for Kenya). Total rainfall is predicted to remain the same but the rainfall intensity is projected to increase, associated with the increase in atmospheric water vapour. In addition, the number of extremely wet seasons is projected to increase to 20% (i.e. 1 in 5 seasons) resulting in more flooding. The change in climate that occurred between 1960 and 2003 and the climate changes predicted by 2060 and 2090 are summarised in the table below.

Actual and Predicted Mean Temperature in Kenya (UNDP 2007)




| | Observed (between 1960 and 2003) | Changes Predicted by GCMs by 2060 | 2090 |
|---|---|---|---|
| Temperature Rise | 1.0°C (0.21 per decade) | 1 – 2.8°C | 1.3 – 4.5°C |
| *'Hot' Days*[2] current climate (% of days) | - | 17 – 45% | 23 - 75 % |
| *'Hot' Nights* current climate (% of days) | - | 32 -75 % | 40 – 95% |
| *'Cold' Days*[3] current climate (% of days) | - | 2 – 5 % | 1 – 3% |
| *'Cold' Nights* current climate (% of days) | - | 0 | 0 |
| Precipitation[4] | No change | No large changes | |
| Heavy Rainfall Events[5] | Possible increase (not statistically significant) | Increase annually, but mainly in rainy season | |
| Maximum 1- and 5-day rainfalls | Inconsistent (not statically significant) | Increase in magnitude in rainy season | |

[1] The temperature difference between the minimum at night and the maximum during the day

[2] 'Hot' day or 'Hot' night is defined by the temperature exceeded on 10% of days or nights in the current climate of that region (average)

[3] 'Cold' days or 'Cold' nights are defined as the temperature for the coldest 10% of days or nights (average)

[4] Model simulations show wide disagreements in projected changes in El Niño (strongly influences seasonal rainfall), contributing to the uncertainty in projection of rainfall, particularly the future inter-annual variability

[5] A 'Heavy' event is defined as a daily rainfall total in the top 5% of daily totals in the current climate of that region

Cranfield UNIVERSITY
WSUP Water & Sanitation for the Urban Poor

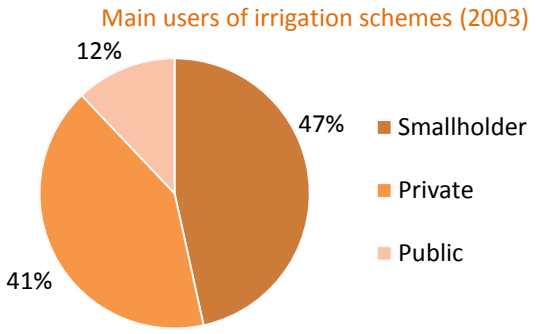
# Water Resources

Kenya is classified as a chronically water-scarce country (8.3% of countries, WB 2009) and has one of the world's lowest per capita water replenishment rates (647 $m^3$ per capita per year, projected to decline to 235 $m^3$ by 2025, Olago, 2009). Despite this water scarcity there has been limited development of the available water resources – only 9% is utilised. As a result the water storage per capita has declined from 11.4 $m^3$ in 1969 to 4.3 $m^3$ in 2006 – principally due to population growth, thus during droughts the volume of water stored decreases rapidly and those dependent on surface water resources very quickly experience water shortages. There are 5 main drainage basins in the country but water is not distributed evenly, so only 2 have surplus water, the rest rely on transfers (canals). Out of 164 sub-basins with perennial river flows, 90 will suffer from surface water deficits by 2010 while 33 sub-basins without perennial river flow already have an apparent water shortage (FAO, 2005). As a result water use conflicts among irrigation, livestock, wildlife and environmental conservation is quite common. This is exacerbated by the long term degradation of catchments, lakes and aquifers (costs the country 0.5% of its GDP annually (WB, 2009)) and an uneven spatial and temporal distribution of resources, making the country very vulnerable to perturbations in water supply, particularly from climate variability (World Bank, 2009). In addition, groundwater resources have been exploited beyond their sustainable yield in the intensively settled parts of the country (in Nairobi the groundwater has been steadily declining). The table above summarises the water resources in the country.

| AQUASTAT FAO (2010) | Date | Value | Unit |
|---|---|---|---|
| **Water Resources** | | | |
| Long-term average annual precipitation | | 365 | $km^3$/year |
| **Long-term average annual renewable water resources** | | | |
| Internal | | 20.7 | $km^3$/year |
| Surface water | | 20.2 | $km^3$/year |
| Total Dam Capacity | 2003 | 4.08 | $km^3$ |
| Ground water | | 3.5 | $km^3$/year |
| External (imported water) | | 10 | $km^3$/year |
| Total | | 30.7 | $km^3$/year |
| Total renewable water resources per capita | 2008 | 792 | $m^3$/year |
| **Water Withdrawn** | | | |
| **By sector** | | | |
| Agricultural | 2003 | 2.165 | $km^3$ |
| Municipal | 2003 | 0.47 | $km^3$ |
| Industrial | 2003 | 0.1 | $km^3$ |
| Total Freshwater Withdrawal | 2003 | 2.735 | $km^3$ |
| Total water withdrawal per capita | 2007 | 72.44 | $m^3$ |
| **Pressure on water resources** | | | |
| Total freshwater withdrawal as percentage of actual renewable water resources | 2007 | 8.909 | % |
| Agricultural water withdrawal as percentage of actual renewable water resources | 2007 | 7.052 | % |

## Irrigation

About 80% of the country is arid and semi-arid, 17% is considered high potential agricultural land which sustains 75% of the population. Is predominantly rainfed, but it is still the main user of water and currently consumes about 80%, while municipal and commercial use accounts for the rest (17% and 3% respectively). About 80% of all people working in agriculture are smallholders (breakdown of irrigation right). Currently irrigation development is lead by the private sector and by smallholder irrigation schemes with great emphasis on sustainable development (AQUASTAT, 2010).




## Drinking Water and Sanitation

Until its recent political setbacks, Kenya appeared to be on track to achieve the Millennium Development Goal (MDG) of 90% water access, though it was off-track to meet its 90% target for sanitation access (USAID, 2009). There are 1800 municipal water supply schemes, out of which 700 are managed by the Ministry of Water Resource Management and Development while communities manage the rest. There are 9000 boreholes, most of which require rehabilitation. The table below summarises the improvements to water and sanitation in urban and rural Kenya (Joint monitoring programme WHO & UNICEF, 2009)

| Year | Urban Population (millions) | Rural Population (millions) | Improved Water Supply (%) | | | Improved Sanitation (%) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Urban population | Rural population | Total | Urban population | Rural population | Total |
| **1990** | 4.3 | 19.1 | 91 | 32 | 43 | 24 | 27 | 26 |
| **1995** | 5.2 | 22.2 | 89 | 38 | 48 | 25 | 28 | 27 |
| **2000** | 6.2 | 25.2 | 87 | 43 | 52 | 26 | 30 | 29 |
| **2005** | 7.4 | 28.2 | 85 | 48 | 56 | 27 | 31 | 30 |
| **2008** | 8.3 | 30.4 | 83 | 52 | 59 | 27 | 32 | 31 |

# MAIN IMPACTS OF CLIMATE CHANGE

Agriculture is the basis of the Kenyan economy and it is very vulnerable to increasing temperatures, droughts and floods, which result in a reduction in maize yields (requiring significant imports), the number of livestock (shortage of forage, increased disease and lack of water) and the output of every major sector of the economy (costing 2.4% of GDP per annum). The arid and semi-arid lands (80% of the country) are particularly vulnerable as their economy is almost entirely dependent on livestock. The population stresses will increase migration which will typically be to urban areas. The increased populations in urban areas will increase competition over natural resources and the likelihood of conflict. In addition, resource scarcity can lead to increased capture of resources by elites exacerbating exiting inequalities. The table below summaries the main impacts of climate change.

| | Increased Temperature | Droughts | Floods | Sea Level Rise |
|---|---|---|---|---|
| Water | • Increase evaporation, decreases hydroelectric potential | • Water scarcity<br>• Lower groundwater<br>• Reduced hydroelectric production[1]<br>• Increased reliance on Imported water<br>• Saline intrusion<br>• Increased vendor water costs<br>• Increased time fetching water<br>• Increased pumping costs | • Detrimental impact on water quality (eutrophication from dissolved fertiliser)<br>• Sedimentation | • Saline intrusion<br>• Increase in flooding and extreme weather |
| Livelhoods | • Crop failure and food insecurity<br>• Change in livestock<br>• Lower maize yields[2]<br>• Reduced production of tea, sugarcane, and wheat<br>• Crop pests more common<br>• Wildlife extinction<br>• Decline in fish stocks | • Death of livestock[3]<br>• Human-wildlife conflict<br>• Conflict between pastoralists and famers<br>• Erosion of top soil and grass seed<br>• Decline in vegetable production<br>• Damage to tourist attractions/ wildlife<br>• Grazing land competition<br>• Increased competition at fishing grounds[4]<br>• Reduction in aquaculture production<br>• Food prices increase at rural markets | • Eroding and washing away of grass seed and topsoil<br>• Destruction of infrastructure (roads, rail, bridges, irrigation, pipes)<br>• Crop loss<br>• Livestock loss<br>• Agriculture and schooling disrupted<br>• Damage to tourist attractions/wildlife<br>• Siltation/destruction of sand dams<br>• Redistribution of nutrients | • Land submerged[5]<br>• Erosion of shoreline damaging infrastructure<br>• Damage to tourist attractions/wildlife<br>• Crops lost |
| Health | • Increase in rift valley fever[6]<br>• Spread of Avian influenza, cholera, ebola, Lyme's disease, plague, tuberculosis, sleeping sickness, yellow fever, red tide and babesiosis | • Starvation[7] and malnutrition<br>• Less water for hygiene and cleaning, increasing water-washed diseases<br>• Increase in water-borne diseases through deterioration of drinking water quality | • Cholera epidemics<br>• Loss of life<br>• Increase in water-borne diseases<br>• Damage to health infrastructure<br>• Food shortages | |
| Biodiversity | • Deforestation[8]<br>• Reduction in growth and regeneration<br>• Reduced biodiversity<br>• Desertification<br>• Forest land degradation<br>• Invasive species<br>• More frequent forest fires[9]<br>• Extended range of pests<br>• Species range shift extinction of species | • Forest fires<br>• Mangroves die back<br>• Increased charcoal production, forest clearing and logging<br>• Increase in disease<br>• Desertification | • Sedimentation<br>• Loss of habitats<br>• Soil erosion | • Food shortages<br>• Mangroves submerged<br>• Displacement of coastal wetlands<br>• Bleaching of coral reefs |

[1] During the drought in 1999/2000, hydropower generation was reduced by over 40%, and Kenyan industry lost Ksh 110 billion (World Bank, 2009)
[2] In 2000 national maize production (staple crop for 90% of the population) declined to 2 million tons from 2.3 million tons in 1999 and the Government had to import 2.6 million bags of maize worth $800 million (MENR, 2009)
[3] Livestock is 12% of GDP and forms 47% of agricultural GDP. In the arid and semiarid lands (80%) livestock accounts for 90% of employment , 95% of income and there are high rates of poverty (60% of families). During the 1999/2000 drought economic loss from livestock deaths was Ksh 11 billion (Kabubo-Mariara, 2009)
[4] When there are no jobs in farming, industry, and tourism, people resort to fishing for subsistence (fishing activities increased more than ten-fold during the 1999/2000 drought (NIDOS, 2009))
[5] The Kenyan coastline is said to be one of the most vulnerable to sea level rise in the world (if the seas rise by only 0.3 m, 17% of Mombasa will be submerged (4600 ha))
[6] Occurs during periods of high humidity, killing livestock (MENR, 2009)
[7] The 1999/2000 droughts resulted in 4.7 million facing starvation
[8] 68% of households use fuel wood as their main energy source for cooking and heating (MENR, 2009)
[9] Over last 20 years Kenya has lost more than 5,700 ha of forests per year to forest fires (MENR, 2009)

# Vulnerability Assessment

A range of global and regional studies have assessed Kenya's vulnerability to climate change using global datasets[1,2,3,4,5] producing indices for each country to enable simple comparison. The table below presents the scores (measure of vulnerability) for Kenya for 9 global indices. The indices, which assess the impact of climate change on water resources, indicate that Kenya only has a medium vulnerability. This is likely a result of the indices being distorted by the larger amounts of water available in the 2 wet catchments - in the arid and semi-arid lands there is chronic scarcity and low utilisation of water resources and climate change will be a major problem. Kenya has a reasonably low social vulnerability indicating that the government and economy are reasonably stable and relatively able to adapt to climate change.

| Index | Score | Vulnerability | How it's calculated |
|---|---|---|---|
| **Water Resources** | | | |
| Water Scarcity Index (2004)[1] | 0.5 | Medium | Water extracted from rivers divided by the low flow (flow exceeded 90% of the time). E.g. If ≥ 1 then consumption exceeds supply |
| Ground Water Dependence (2004)[1] | 0.25 | Medium | Ground water withdrawn as a fraction of total water withdrawn in region |
| Total freshwater withdrawal as percentage of total renewable freshwater resources (2009)[2] | 8.9% | Medium | Total freshwater withdrawn in a given year, expressed as percentage of the total actual renewable water resources. It is an indication of the pressure on the renewable freshwater resources (data from 1998-2002) |
| Annual Renewable Water Supply per capita (Projections for 2025)[2] | 840 $m^3$/capita | Scarcity | Runoff (data from 1950-2000) divided by Population (2025) (prediction from UN population division) |
| **Social Vulnerability** (1st = lowest vulnerability) | | | |
| Human Vulnerability A (2007)[3] | 0.578 | 30th /49 (Africa) | Social vulnerability to climate change (the index consists of 5 weighted factors, each of which is scored). In HVA the factors are: economic well being and stability (20%), demographic structure (20%), global interconnectivity (10%) and dependence on natural resources (10%); HVB also includes institutional stability and infrastructure (corruption) (40%) |
| Human Vulnerability B (HVB, includes corruption) (2007)[3] | 0.603 | 11th / 49 (Africa) | |
| Sensitivity and Adaptability (2007)[4] | 0.541 | 147th / 182 (global) | Human Development Index (used as generic indicator for adaptive capacity) |
| Sensitivity Index (2004)[1] | 3 | Medium | Combination of Water Scarcity Index, GW Dependence and Sensitivity and Adaptability Index |
| Climate Vulnerability Index (2007)[5] | - | Medium-High | The index links water resource modelling with human vulnerability assessments to contribute to a meaningful assessment for generic use |

[1] Petra Döll (2009) Vulnerability to the impact of climate change on renewable groundwater resources: a global-scale assessment. *Environmental Res. Letters* 4 (3).
[2] World Business Council for Sustainable Development Global Water Tool (2009). Available at: www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?type=p&MenuId=MTUxNQ&doOpen=1&ClickMenu=LeftMenu
[3] Vincent, K. (2004) Creating an index of social vulnerability to climate change for Africa. Tyndall Centre Working Paper 56.
[4] Human Development Index (2009). Available at: hdr.undp.org/en/statistics
[5] Centre for Ecology and Hydrology (2007) Oxford Centre for Water Resources. The Climate Vulnerability Index. Available at: ocwr.ouce.ox.ac.uk/research/wmpg/cvi/

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Tom Heath 2010 Cranfield University t.t.heath@cranfield.ac.uk