Africa Transformation-Ready: The Strategic Application of Information and Communication Technologies to Climate Change Adaptation in Africa

Final Report

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Acronyms

AAP	Africa Adaptation Programme
ABN	Niger Basin Authority
ACMAD	African Centre of Meteorological Applications for Development
AEC	African Economic Community
AEWAS|ViGIRisC	African Early Warning and Advisory Climate Services|Projet de Vigilance et Gestion Intégrée du Risque Climatique en Afrique
AfDB	African Development Bank
ALP	Adaptation Learning Programme
ALUCCSA	Adaptation of Landuse to Climate Change in Sub-Saharan Africa
AMCEN	African Ministerial Conference on the Environment
AMCOST	African Ministerial Council on Science and Technology
AMCOW	African Ministerial Council on Water
ANCR	National Autoevaluation of Capacity to Reinforce
ARC	AGRHYMET Regional Center
ARTEMIX	Real Time Environmental Monitoring Information System
AU	Africa Union
BCPR	Bureau for Crisis Prevention and Recovery
BMZ	German Federal Ministry for Cooperation and Development
CAADP	Comprehensive Africa Agriculture Development Programme
CARPE	Central African Regional Program for the Environment
CCAA	Climate Change Adaptation Support Programme for Action-Research and Capacity Development in Africa
CCAPS	Climate Change and African Political Stability
CC-DARE	Climate Change Adaptation and Development Initiative
CDM	Clean Development Mechanism
CDSF	ClimDev-Africa Special Fund
CEN-SAD	Community of Sahel-Saharan States
CFIS	Community Flood Information System
CILSS	Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel
CKW	Community Knowledge Workers
ClimDev-Africa	Climate for Development in Africa
COMESA	Common Market for Eastern and Southern Africa
CONGAD	Council of Non-Governmental Organizations to Support Development
CRM TASP	Climate Risk Management Technical Assistance Support Project
CVCA	Climate Vulnerability and Capacity Analysis
DEWS	Distance Early Warning System for Tsunamis

DFID	UK Department of International Development
DNA	Designated National Authorities
DSSAT	Decision Support System for Agrotechnology transfer
EAC	East African Community
EC	European Commission
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
ENDA-TM	Environnement et Développement du Tiers Monde
ENSO	El Niño/La Niña-Southern Oscillation
EU	European Union
FANPRAN	
FAO	Food and Agriculture Organization
GCM	General Circulation Models
GDP	Gross Domestic Product
GEF	Global Environmental Fund
GGWSSI	Great Green Wall for the Saharan and Sahel Initiative
GHG	Green House Gas
GIEWS	Global Information and Early Warning System
GIGS	Geospatial Integrity of Geoscience Software
GIS	Geographical Information Systems
GIZ (formerly GTZ)	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GPRS	General Packet Radio Systems
GPS	Global Positioning System
GSM	Global System for Mobile
GTOS	Global Terrestrial Observing System
GWP	Global Water Partnership
HP	Hewlett Packard
ICPAC	Climate Prediction and Application Centre
ICT	Information and Communication Technology
ICT4D	Information and Communication Technology for Development
IDRC	International Development Research Centre
IDS	Institute of Development Studies
IFPRI	International Food Policy Research Institute
IGAD	Intergovernmental Authority on Development
IISD	International Institute for Sustainable Development
IPCC	International Panel on Climate Change
ISRA	l'Institut Sénégalais de Recherches Agricoles (ISRA)
ITU	International Telecommunication Union
IUCN	International Union for Conservation of Nature

LDC	Least Developed Countries
LDCF	Least Developed Countries Fund
MAREN	Malawi Research and Education Network
MDG	Millennium Development Goals
MDW	Moroccan Department of Water
M-PESA	Mobile Pesa
NAPA	National Adaptation Plan of Action
NASA	National Aeronautics and Space Administration
NBA	Niger Basin Authority
NBI	Nile Basin Initiative
NCST	National Commission for Science and Technology
NDP	National Development Plan
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
OSFAC	Observatoire Satellital des Forêts d'Afrique
PANE	National Environmental Action Plan
RCDF	Rural Communications Development Fund
RCMRD	Regional Center for Mapping of Resources for Development
RECABIP	Regional Capacity Building Partner
RECs	Regional Economic Communities
REDD	Reducing Emissions from Deforestation and Forest Degradation
RFID	Radio Frequency Identification
RHOK	Random Hacks of Kindness
RISOCAS	Developing Rice and Sorghum Crop Adaptation Strategies for climate change in vulnerable environments in Africa
RRSU	Regional Remote Sensing Unit
RS	Remote Sensing
SADEAT	South African Department of Environmental Affairs and Tourism
SAR	Synthetic Aperture Radar
SMS	Short Message Service
UEMOA	West African Economic Monetary Union
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nation Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention for Climate Change
USAID	United States Agency for International Development
VSAT	Very Small Aperture Terminal
WIMAX	Worldwide Interoperability for Microwave Access

WISDOM	Water-related Information System for the Sustainable Development of the Mekong Delta in Viet Nam
WMO	World Meteorological Organization

Chapter 1 - Introduction and Conceptual Framework

The past decade has seen a fundamental shift in understanding throughout the world regarding the unavoidable need to adapt to the impacts of climate change. Scientific evidence has demonstrated strongly and increasingly clearly that human-induced climate change has already begun[1] and analysis of the implications of this process suggests that ecological, economic and social impacts will be largely adverse[2]—particularly for the least developed countries of the world, the majority of which are in Africa. Their limited financial, institutional and human resources, high dependency on ecosystem-dependent economic and livelihood activities (such as agriculture, fisheries and pastoralism), and existing problems such as land degradation, disease and social conflicts reduce their capacity to respond effectively to current and future climate stresses.

African countries are preparing for and responding to the potential consequences of climate change by building their understanding of climate science, assessing their vulnerability to projected impacts, identifying priorities for adaptation, developing plans and strategies, and implementing targeted adaptation measures. Information and Communication Technologies (ICTs) could play an important role in support of these efforts. However, understanding of their potential is currently limited.

This report is the outcome of research commissioned by the African Development Bank and the World Bank Group, with the support of the African Union, to explore the transformative potential of ICTs in addressing the major economic, environmental and social challenges facing the African continent due to the impacts of climate change. It is one of several sector-based studies commissioned with a view to preparing a flagship report under the "Transformation Ready" theme.

The International Institute for Sustainable Development (IISD) was commissioned to undertake the sectoral study and to identify positive and potentially replicable practice in the use of ICTs for climate change adaptation, drawing on case studies in three countries- Senegal, Uganda and Malawi. The study has explored the barriers, opportunities, implementation risks and challenges concerning the use of ICTs for adaptation to climate change, and assessed the stakeholders involved. Experience with ICTs that emerged during an extensive literature review, interviews, survey analysis, focus group events and workshops has contributed to a scan of evidence and experience, an analysis of the current landscape, case studies and appendices to this report. Emerging practices and findings have helped to identify

[1] Intergovernmental Panel on Climate Change. (2007). Summary for policymakers. In S. Solomon, D. Qin, M. Manning, Z. Chen, Z., M. Marquis, K.B. Averyt, M. Tignor & H.L. Miller. (eds.). *Climate Change 2007: The physical science basis*. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (pp.1-18). Cambridge, U.K.: Cambridge University Press.

[2] Intergovernmental Panel on Climate Change. (2007). Summary for Policymakers. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (eds.), *Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 7–22). Cambridge, U.K.: Cambridge University Press.

potential strategic interventions and to guide the formulation of recommendations to scale up ICT interventions for adaptation.

Overall, the research entailed the following:

- Stocktaking of good practices and emerging uses of ICTs and how these can contribute to the transformation of existing business models in climate change adaptation.
- Identification of applications and models that have significantly impacted places in Africa or elsewhere, and understanding of their potential for broader portability and scalability.
- Understanding the barriers and constraints to transformative ICT implementations and the scaling up of effective models, the opportunities for their deployment, and the multi-stakeholder partnerships needed for successful implementation.

The methodology for the study is described in Appendix 1.

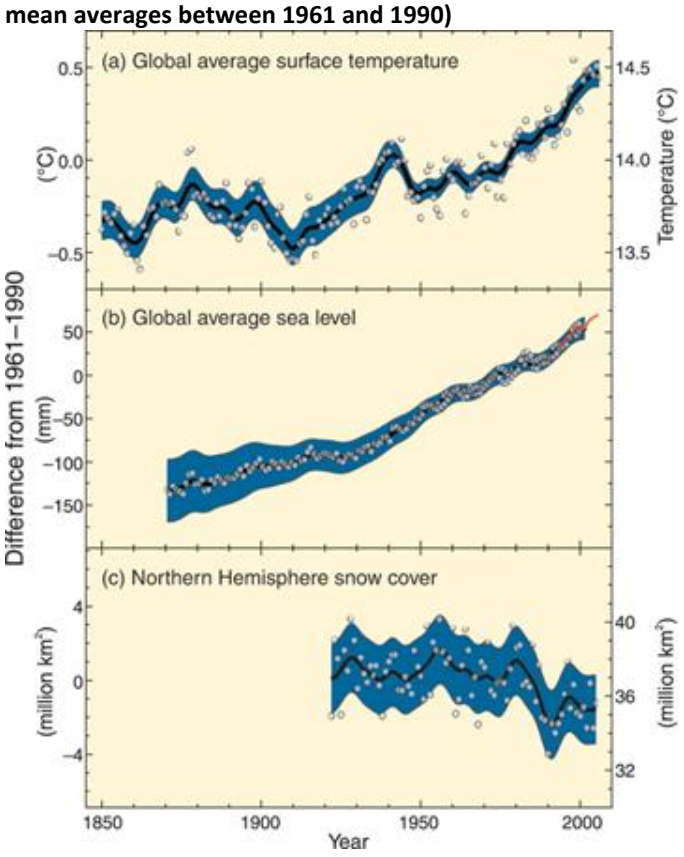
The report is structured as follows:

- Chapter 1 presents a global overview of climate change and current trends, of impacts on the African continent; and of climate change adaptation which is taking place today in Africa. It also describes a framework which can be used to assess ICT tools and their role in climate change adaptation.
- Chapter 2 examines the landscape and presents an analysis of climate change adaptation action in Africa. It assesses existing adaptation policies and strategies, and focuses specifically on those that make use of ICTs. It describes a sample of adaptation projects and programs currently underway in Africa that respond to priorities identified by governments.
- Chapter 3 explores the potential role of ICTs in addressing climate change, highlighting some of the challenges and opportunities in applying ICTs for adaptation.
- Chapter 4 presents three country case studies, of Uganda, Malawi and Senegal, highlights their particular climate change challenges and ICT landscape, and describes some examples of projects where ICTs have been applied in supporting adaptation.
- Chapter 5 sets out the conclusions and recommendations that have emerged from the scan and landscape analysis.

1.1 Climate change around the world and in Africa: current trends

Through exhaustive and continuous research, the international community has concluded that an "unequivocal"[3] warming of the climate system is taking place. Between 1906 and 2005, mean annual global temperatures increased by an average 0.74°C. The vast majority of scientists and scientific organizations[4] agree that this rise in global temperatures is due to an increase in greenhouse gases[5] in the Earth's atmosphere due to human actions such as the burning of fossil fuels, and to land use change associated with agriculture and forestry. Even if the release of greenhouse gases were to end today, global temperatures will continue to rise because of the natural inertia within the Earth's atmospheric and terrestrial systems. As a result, the world is locked into a pattern of climatic change, the scope and consequences of which remain uncertain. However, in the words of the Royal Society, "the risks associated with some of these changes are substantial."[6] This section of the report provides a brief overview of trends associated with climate change at the global level and specifically in Africa.

Figure 1-1: Global average changes in surface temperature, sea level and snow cover between 1850 and 2010 (compared to mean averages between 1961 and 1990)



Source : IPCC. http://www.ipcc.ch/graphics/syr/fig1-1.jpg

[3] Allali et al. (2007). *Climate Change 2007: Synthesis Report*. Intergovernmental Panel on Climate Change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

[4] These international scientific organizations include the International Energy Agency, World Meteorological Organization, National Aeronautics and Space Administration, Arctic Council, Royal Society, and the US Global Change Research Program.

[5] Greenhouse gases include carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride, as well as indirect gases (which can become the previously gases) such as sulfur dioxide, nitric oxide and nitrogen dioxide, carbon Monoxide and non-methane volatile organic compounds.

[6] The Royal Society (2010). Climate Change: A summary of the science. Available at: http://royalsociety.org/climate-change-summary-of-science/.

1.1.1 Global climate change trends

Signs of a changing global climate are already emerging, as demonstrated in Figure 1-1. Measured temperatures have risen since the end of the 19th century, with this process accelerating during the latter half of the 20th century.[7] The change has not occurred uniformly throughout the world: the Arctic, for example, has warmed at a rate that is twice that of the rest of the world over the past few decades.[8] Along with changing temperatures, there has been an increase in the frequency and intensity of extreme weather events and greater weather variability. In its Fourth Assessment Report released in 2007, the Intergovernmental Panel on Climate Change (IPCC) reported a high likelihood that higher temperature days are becoming more frequent, along with heat waves and more frequent heavy precipitation events.[9] World Meteorological Organization findings since the IPCC's 4th Assessment Report highlight 35 extreme weather events between 2001 and 2010, and suggest that the year 2010 saw some of the most extreme conditions on record in many regions.[10] Further indications of on-going climate change include a marked decline in glacial cover and a rise in sea level. On average, global sea levels have risen by 1.81 mm per year from 1961 to 2003, with the trend accelerating in the latter decades.[11]

Projected changes in climate at the global level through to 2100 have been modelled by the IPCC using a number of scenarios based on different development paths of population growth and economic structures.[12] While differing in their outcomes, all scenarios predict significant continued warming of the Earth's surface by 2011—ranging from 1.1 to 6.4°C (see Figure 1-2). Projections for the same period suggest that global sea levels will rise by between 0.18 and 0.59 metres due to thermal expansion of warming oceans alone;[13] further increases could be caused by the melting of sea ice.

Impacts are not expected to be uniform, with higher temperature increases expected over land masses and in northern latitudes (see Figure 1-2). Climate scenarios used by the IPCC project that snow cover will continue to contract and that Arctic and Antarctic sea ice will shrink. It is also very likely that in future there will be more frequent instances of extreme temperatures, heat waves and heavy precipitation events.[14] Tropical cyclones are projected to become more intense, with higher wind speeds and heavier precipitation.[15]

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[7] National Aeronautics and Space Administration. *Uncertainties – Unresolved questions about Earth's climate*. National Aeronautics and Space Administration. Available at: http://climate.nasa.gov/evidence/

[8] Susan Joy Hassol (2004). Impacts of a Warming Arctic – Arctic Climate Impact Assessment. Cambridge University Press.

[9] Allali et al. (2007). *Climate Change 2007: Synthesis Report*.

[10] World Meteorological Organization, (2001) *Weather Extremes in a Changing Climate: Hindsight on Foresight*. WMO. Available at: http://www.wmo.int/pages/mediacentre/news/documents/1075_en.pdf

[11] Allali et al. (2007). *Climate Change 2007: Synthesis Report*.

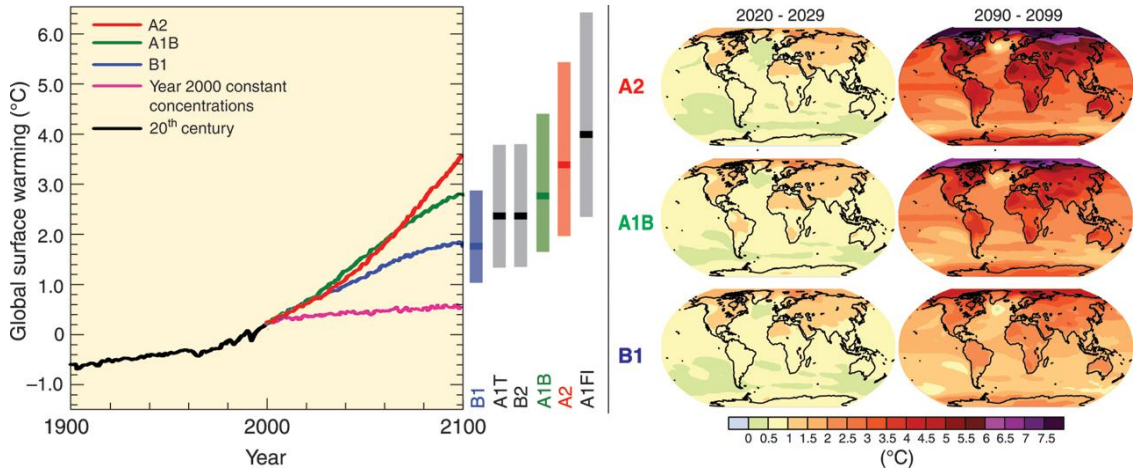
[12] Details on the various scenarios are available in Allali et al. (2007). *Climate Change 2007: Synthesis Report*, page 44.

[13] Allali et al. (2007). *Climate Change 2007: Synthesis Report*.

[14] Ibid.

[15] Ibid.

Figure 1-2: Global Surface Warming Scenarios 2000 – 2100



Source: IPCC. http://www.ipcc.ch/graphics/syr/fig3-2.jpg

Some uncertainty[16] remains regarding all of these projections. This is due to a number of factors including a lack of certainty regarding future emissions of greenhouse gases, development paths and population patterns; different approaches to scenario development; and insufficient weather data, particularly in some parts of the world (including Africa).[17] The development of climate projections is an inexact science. However, while it is not possible to be certain, there is a high degree of confidence among climate scientists about the continuation of trends which can be currently observed.

1.1.2 Climate trends in Africa

Like other regions of the world, Africa is beginning to experience the impacts of human-induced climate change. Decadal increases in temperature of between 0.1 and 0.3 °C have been observed across the continent,[18] with indications that Africa is warming faster than the global average.[19] Observed changes suggest that rainfall patterns are becoming more variable across the continent, reflecting the influence

[16] In its Fourth Assessment Report, the IPCC addresses uncertainty through an assessment of the level of agreement on findings, the likelihood of an event or projection occurring, and the degree of confidence in a projection or event. For more about the IPCC treatment of uncertainty, see: Allai et al, 2007: 27.

[17] A lack of weather data is a particular problem in Africa: http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter9.pdf

[18] Boko, M., et al. (2007). Africa. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (pp.433-467). Cambridge UK: Cambridge University Press.

[19] Conway, Gordon (2009). The Science of Climate Change in Africa: Impacts and adaptation. Imperial College: London.

of factors such as the El Niño/La Niña-Southern Oscillation (ENSO).[20] There is also a strong hypothesis that warming in the south Atlantic and Indian Oceans has led to a weakening of monsoons, depriving the Sahel region of rainfall in recent years.[21]

Reflecting regional differences in climate and ecosystems, these observed changes in climate parameters have not occurred uniformly across Africa:

- In *East Africa* temperatures have risen by an average of 1.3°C since 1960.[22] Precipitation patterns have altered and there is a reported increase in the frequency of droughts and floods.[23] Since 1912, Mt Kilimanjaro's ice fields have decreased in total area by around 80 percent.[24]
- In *North Africa* significant warming has occurred during the summer while winters are becoming drier.[25] Sahelian Sudan experienced a 25 percent decrease in rainfall during the last quarter of 20th century.[26]
- In *Southern Africa* decadal warming of 0.1 to 0.3°C occurred between 1961 and 2000,[27] while the duration of the dry season lengthened between 1961 and 2005.[28]

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[20] Boko, M., et al (2007). The El Niño-Southern Oscillation (ENSO) is a natural process that occurs every three to seven years within the Pacific Ocean and influences climate patterns in nearly all parts of the world. The process involves an initial El Niño phase in which the easterly trade winds of the southern hemisphere weaken, reducing the movement of warm water away from the coast of Peru and towards Indonesia, and therefore leading to less upwelling of cold water along the coast of South America. This process leads to higher air surface pressure over Indonesia and a consequent further reduction in the strength of the trade winds (and sometimes their reversal). As the pool of warm water in the Pacific expands eastward, surface air pressure near South America becomes lower. These El Niño processes result in greater occurrence of drought in southeast Asia and Australia, and greater rainfall in the normally dry regions of eastern South America. The La Niña phase that then follows involves a reversal of this pattern, with greater cooling of water in the eastern Pacific Ocean leading to high air surface pressure and very dry conditions in South America and the opposite conditions in southeast Asia and Australia. Scientific understanding of the mechanisms behind this phenomenon is incomplete. Conway, G.(2009). *The science of climate change in Africa: impacts and adaptation.* Imperial College London. From: https://workspace.imperial.ac.uk/climatechange/Public/pdfs/discussion_papers/Grantham_Institue_-_The_science_of_climate_change_in_Africa.pdf

[21] Conway, G. (2009). *Ibid*

[22] McSweeney, C., New, M. and Lizcano, G. (2009b). UNDP Climate Change Country Profiles: Uganda. Accessible here: http://country-profiles.geog.ox.ac.uk/index.html?country=Uganda&d1=Reports

[23] Adaptation Fund [AF] (2011). Project/Program Proposal: Implementation of concrete adaptation measures to reduce vulnerability of livelihood and economy of coastal and lakeshore communities in Tanzania. Submitted by UNEP and the Vice President's Office, Division of Environment. Accessible here: http://www.adaptation-fund.org/node/1087

[24] Seitz, Joseph and Dr. Wilfred Nyangena (2009). Economic Impact of Climate Change in the East African Community. Prepared with support of Global 21 Consulting and GIZ. Accessible here: http://www.global21.eu/download/Economic_Impact_Climate_Change_EAC.pdf

[25] Trenberth, K.E., et al. (2007). Observations: Surface and Atmospheric Climate Change. In Solomon, S. et al. (Eds.). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 235-336). Cambridge, United Kingdom and New York, NY: Cambridge University Press.

[26] Hulme, M., Doherty, H., Ngara, T., New, M., and Lister, D. (2001). African Climate Change: 1900-2100. *Climate Research*. 17: 145-168.

[27] Boko, M. et al (2007).

[28] Boko, M. et al (2007).

- *West Africa* has seen substantial reductions in rainfall during the latter half of the 20th century,[29] including prolonged droughts in the 1970s and 1980s,[30] and greater rainfall variability.[31]

The findings of Global Circulation Models project that current trends of rising temperatures and altered rainfall patterns will continue during the remainder of this century. At a continental level, temperatures are projected to rise by between 3.2°C and 3.6°C by the period 2080-2099.[32] Precipitation patterns will also continue to change—very likely decreasing along the Mediterranean coast, Northern Sahara and west coast to 15°N, while increasing in tropical and eastern Africa.[33] An increase in the number of extreme climate events experienced within the continent is likely to accompany these changes in climatic averages.[34] Rising sea levels are also projected to affect Africa's coastline, particularly the eastern coastline, as well as island states.[35]

It is important to note that significant uncertainty remains about projected changes in Africa's climate, due to a lack of modelling capacity, insufficient climate data and the "relatively crude"[36] Global Climate Models used to simulate scenarios. As a result, many researchers are "still not confident" about climate trends at either the continental or local level. Global Climate Models "work to a spatial resolution of several hundred kilometers [and] do not take full account of the topographic, vegetation and land-use diversity in the landscape."[37] Furthermore, there is a "paucity of regular, detailed information on African weather"[38] – the result in part of a shortage of weather stations compared to other areas of the world, particularly in Central Africa and the Horn of Africa. The total number of stations in Africa is one eighth of that recommended by the World Meteorological Organization.[39] In addition, the drivers of climate in Africa, such as the processes that move the Intertropical Convergence Zone and spur the formation of tropical monsoons, along with ENSO patterns, are not yet fully understood.[40] Despite these uncertainties, projections provide a general idea of what may occur due to climate change over the next century, and improved modelling will continue to provide greater confidence.

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[29] Boko, M. et al (2007).
[30] Sahel and West Africa Club (2009). *Climate Change in West Africa, Sahelian Adaptation Strategies*. SWAC Briefing Note #3 January 2009. Paris, France: SWAC. Retrieved from http://www.oecd.org/dataoecd/33/39/42139680.pdf
[31] Niassé, M. (2007). Elements of a regional climate change adaptation strategy based on the risk sharing approach: West Africa; final report. Dakar, Sénégal: The International Development Research Center.
[32] Christensen, J.H., et. al. (2007). Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[33] Boko, M. et al (2007).
[34] Boko, M. et al (2007).
[35] Allali et al (2007).
[36] Conway, Gordon (2009).
[37] Conway, Gordon (2009).
[38] Conway, G. (2009).
[39] Conway, G. (2009).
[40] Conway, G. (2009).

1.2 Vulnerability of Africa to Climate Change

Changing precipitation patterns, glacial melt, rising sea levels, and more extreme events—as described above, climate change is already affecting ecosystems and the ways in which they underpin human societies. As a result, climate change is rapidly becoming, in the words of the 2007/8 Human Development Report, "the defining development issue of our time." The degree of its influence on development varies over time and space in response to the vulnerability—the potential of a system to be harmed—of a society or region.

Within the context of climate change, vulnerability can be described as the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes (see Box 1-1). A system's vulnerability to climate change is understood to be a function of its exposure and sensitivity to impacts, as well as its capacity to cope with or adapt to these. Exposure is largely determined by geography, as some people and resources ('assets') are located where climate hazards are more likely to occur (*e.g*. on floodplains and by coasts). 'Sensitivity' to these hazards measures how easily a system responds or is affected by perturbations; while 'adaptive capacity' refers to a system's ability to access resources and entitlements that help respond to threats. Factors including available technology, human skills training and access to financial services, as well as broader institutional structures and patterns of decision-making, are considered to be critical determinants of adaptive capacity.[41] This understanding of vulnerability implies that climate events of similar magnitude, such as droughts, that occur in different parts of the world will have different degrees of impact on different socio-economic systems because local capacity to cope with these in each location is also different.

Given this, it should be no surprise that the world's poor are especially vulnerable to climate change. Low incomes, small asset bases, marginal living conditions and low levels of human development limit the capacity of the poor to manage climate risks. Moreover, many of the world's poor live in rural areas, are highly dependent on natural resources and engaged in climate-sensitive livelihoods. As climate change makes risks more difficult to manage, coping mechanisms can be overwhelmed, resulting in increases in the number of poor people and potentially locking them into deprivation and insecurity. Box 1-1 shows some examples of linkages between poverty and vulnerability to climate change.

[41] Yohe (2001), introducing the term adaptive capacity.

Box 1-1: Examples of vulnerability of poor people to climate change

The ability of poor people to draw on assets to cope with climate-related impacts is generally weaker than that of those with more assets or income. The resources at the disposal of the poor are often less resilient and their ability to recover from both slow and rapid-onset events is consequently weak. Low physical, financial and human capital asset levels lead to extreme vulnerability of households:[42]

- Cluster analysis of 294 households in Ethiopia revealed that poor farmers – in particular young agro-pastoralists – were more vulnerable when compared to households with larger landholdings.
- The poorest in a Bolivian community – including elderly people, single women, and subsistence farmers with scarce resources who are often unable to work due to lack of opportunities or physical inability – face greater difficulties coping with the impacts of climate change. These families are less likely to be able to migrate to seek new economic opportunities due to lack of resources. They are more likely to endure hardship and rely on neighbors and other family members for assistance.
- A survey of households surveyed in Mozambique suggests that about 25% did not identify any *ex ante* coping strategies for managing drought and that 45% did nothing to prepare for floods or cyclones. A lack of resources to cope with these events could be a factor contributing to this sense of resignation and disempowerment.

Poverty status and lack of assets can lead vulnerable households to pursue short-term measures which are at odds with long-term sustainability, such as withdrawing children from school. Poverty and lack of resources can lead to maladaptation to climate change and thereby perpetuate or accentuate vulnerability.

African countries are especially vulnerable to the impacts of climate change for three interrelated, mutually reinforcing reasons:

1. Africa's climate is likely to be more severely affected by climate change than other regions, as recent data suggest that it is warming faster than the global average.
2. Its major economic sectors are climate-sensitive.
3. Low levels of human development (income, education, health) and the greater presence of other stress factors (such as conflict and disease) constrain adaptive capacity.

The observed and anticipated impacts of climate change in African countries speak to its greater vulnerability. The Human Development Report identifies five major "transmission mechanisms" through which climate change will affect human development:[43]

- **Losses in agricultural production and food security**: Crop yields are expected to decline as the area suitable for agriculture becomes smaller, growing seasons become shorter and less

[42] EACC (2009)
[43] Human Development Report (2008). *Fighting climate change: human solidarity in a divided world.* UNDP. From: http://hdr.undp.org/en/media/HDR_20072008_EN_Overview.pdf

predictable, and extreme temperature and rainfall events become more frequent.[44] Africa is expected to suffer the largest losses in agricultural output potential.[45]

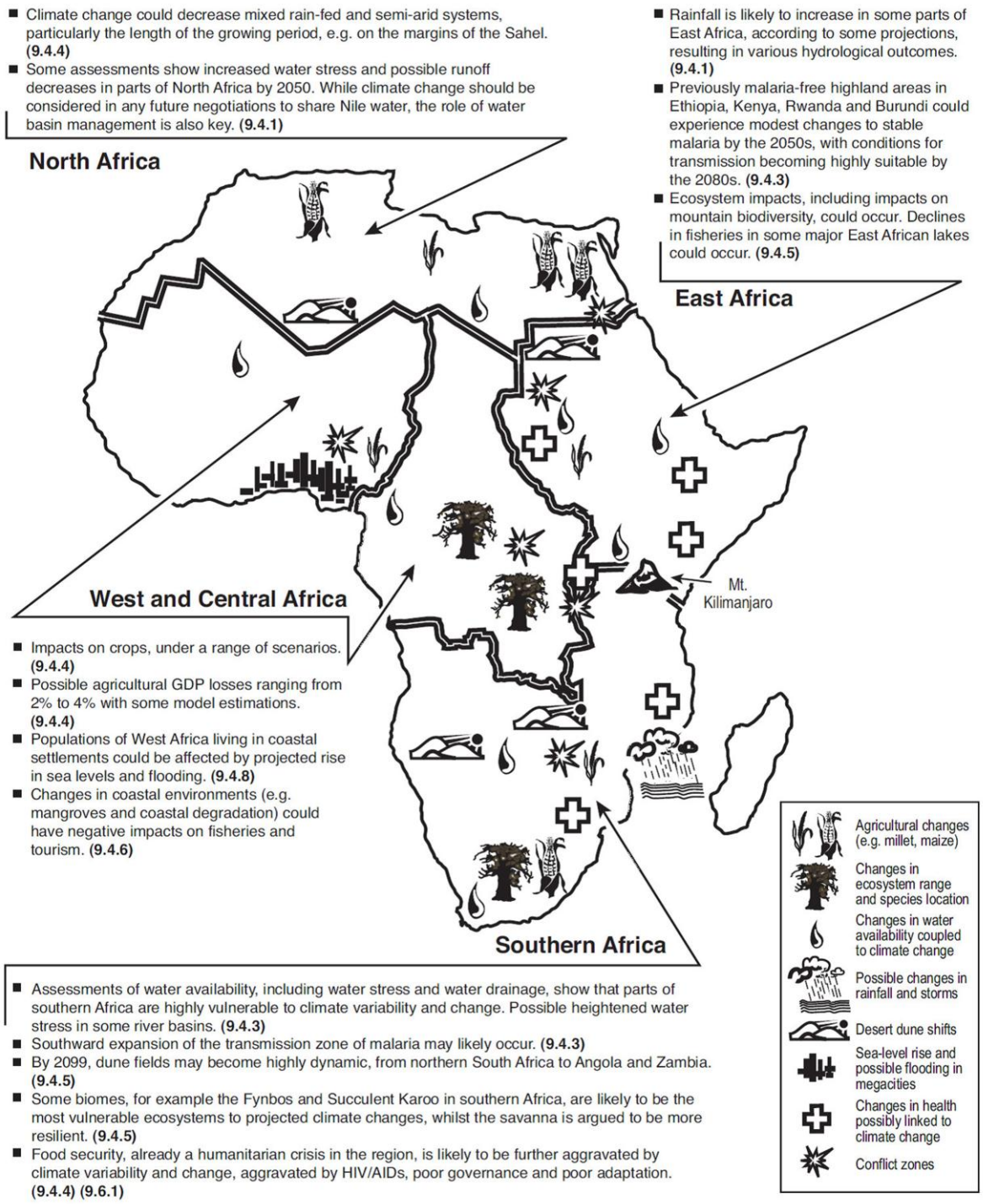
- **Increased water stress and water insecurity**: Many countries in Africa are already reaching the limits of their water resources and climate change will amplify this situation, although not uniformly. The number of people experiencing water stress is likely to increase in northern and southern Africa, while the opposite is likely to happen in eastern and western Africa.
- **Rising sea levels and exposure to climate disasters**: Coastal inundation will destroy infrastructure, leading to the salinization of land and water sources, degradation of ecosystems and displacement of people. More frequent and intense extreme events, such as cyclones and droughts, will increase disaster-related losses.
- **Transforming ecosystems and biodiversity**: Coral bleaching, ocean acidification, warmer inland lakes and shifts in species ranges are pushing many ecosystems beyond their capacity to adapt to changing climate conditions.
- **Increased human health risks**: There will be an expansion and contraction of climatically suitable areas for malaria. The likelihood of malaria epidemics may increase since previously unaffected populations will not have the genetic modifications to protect against infection.[46]

Figure 1-3 which is taken from the IPCC's Fourth Assessment Report, highlights some of the current and possible future impacts and vulnerabilities related to climate change.

[44] Boko et al. (2007); Collier et al. (2008)
[45] Cline (2007).
[46] Boko, M. et al. (2007).

Figure 1-3: Examples of current and possible future impacts and vulnerabilities associated with climate variability and climate change for Africa

N.B.: these are indications of possible change and are based on models that currently have recognised limitations



From: Boko et al (2007: 451)

While these impacts will present themselves in different ways and with varying degrees of severity in different regions and countries, they are likely to translate into significant development losses, particularly in sub-Saharan Africa. Many will be irreversible and efforts to achieve the Millennium Development Goals (MDGs) or sustain progress in the areas covered by these, are likely to be compromised.[47]

1.3 Understanding adaptation

Avoiding significant human development setbacks due to climate change requires urgent action. Such action is typically categorized as either mitigation or adaptation.

Mitigation is concerned with actions to reduce the concentration of greenhouse gases in the atmosphere, either by reducing emissions or by enhancing storage in terrestrial carbon sinks such as soils and forests. The former can involve activities such as switching to renewable energy sources such as wind or solar power, designing buildings to be more energy efficient, policies supporting compact community development that reduces reliance on motor vehicles, and standards or other measures to prolong the active life of manufactured goods. Activities to enhance sinks include expanding natural carbon storage locations, such as forests and wetlands, and the capture and storage of carbon dioxide released into the atmosphere by burning fossil fuels during industrial processes.

Adaptation, on the other hand, is concerned not with the prevention of climate change but with adjustment to its consequences. Even if the most ambitious mitigation plans were implemented today, they would not be sufficient to avoid changes in the global climate. The Earth is now certain to experience some degree of temperature increase and therefore natural and human systems will have to endure some change. Adaptation is defined by the IPCC as "adjustments in human and or natural systems in response to actual or expected changes in climate to reduce adverse impacts or take advantage of opportunities."[48] Strategies might include: reinforcing infrastructure so that it is able to withstand more storm activity; better managing water resources so there is sufficient supply to sustain people through longer dry periods; improving disaster preparedness and relief programs in anticipation of greater demand; and developing drought resistant crop varieties. The amount of adaptation needed will ultimately depend on how much mitigation is achieved.

Adaptation takes place at all levels, from individual and household decisions to national and international policies. It can be anticipatory or reactive, supply-driven or demand-driven, private and

[47] UNDP (2007/2008).
[48] IPCC (2001).

Table 1-1: Relevant types of adaptations, their definitions and examples with focus on agriculture

Type of adaptation		Definition	Examples
Autonomous		Actions that can be taken by farmers and communities independently of policy, based on a set of technology and management options available under current climate conditions	• Crop calendar shifts (planting, input schedules, harvesting) • Cultivar changes • Crop mix changes
Planned (non-autonomous)		Actions that require concerted action from local, regional and/or national policy	• Land use incentives • Pollution control form inputs • Water costing • Germplasm Development Programs
Two types of planned adaptations:	Supply-side	Influencing the accessibility of resources and inputs	• Building water reservoirs to collect rainwater • Expanding drainage infrastructure as a major way to accommodate heavy precipitation events
	Demand-side	Influencing behaviour of individuals and organizations towards certain behaviour	• Water-metering to support water conservation • Changing standards such as construction codes, limits per unit of production, or environmental standards to address changes in climate

Sources: (1) Tubiello F. N. and C. Rosenzweig (2008). Developing climate change impact metrics for agriculture. *The Integrated Assessment Journa*l 8(1): 165–184. (2) Bizikova, L., T. Neale and I. Burton (2008). *Adapting to Climate Change – Handbook for Canadian communities*. Environment Canada and University of British Columbia, Vancouver, pp. 95.

public, autonomous or planned.[49] Table 1-1 provides some examples of these different characteristics of adaptation illustrated by examples from the agriculture sector.

Over the past decade, understanding has grown of how to enable adaptation to climate change across a range of geographic scales, a diverse array of sectors and along different timelines. Four insights in particular have become influential:

- *The intimate connection between adaptation and sustainable development.* By tackling the underlying economic, social and ecological factors that limit the capacity of communities and countries to respond to changing climate conditions, sustainable development can contribute to adaptation action. On the other hand, development activities that do not take into

[49] Füssel (2007); Parry et al. (2008); Bizikova et al. (2008).

consideration near and longer term climate change have the potential to undercut adaptive capacity over time and threaten prior progress.[50]

- *The place-based nature of adaptation*. Adaptation planning and implementation need to be undertaken in response to local circumstances and capacity,[51] while being supported by government policies and actions that create an enabling environment for adaptation.[52]
- *The need for an integrated approach.* Adaptation is a long-term, continual process that cannot be effectively undertaken separately from on-going development and governance processes. The impacts of climate change need to be integrated into everyday decision and policy-making processes if they are to be efficiently and effectively addressed.
- *The potential for trade-offs.* As with many development efforts, the implementation of one adaptation action may have negative repercussions in the near or long term for different groups or sectors—potentially lowering their adaptive capacity. These trade-offs need to be understood and recognized when determining appropriate adaptation strategies.[53]

This understanding of adaptation, particularly its close inter-relationship with sustainable development and the need for it to be integrated into everyday decision and policy-making processes, directly influences the role of ICTs in reducing vulnerability to climate change.

1.4 ICTs in Africa

The ICT infrastructure in Africa has developed greatly in recent years, reflecting the growth of technology and telecommunications on the continent, particularly the rapid take-up of mobile telephony and the deployment of new undersea fibre cable infrastructure.[54]

- The number of mobile telephone subscriptions in sub-Saharan Africa reached 53 per 100 inhabitants by the end of 2011, according to the International Telecommunication Union (ITU).[55]

[50] For example, current development efforts may encourage people to live in low lying areas that are increasingly hazardous due to climate change, or remove supports systems that households rely upon in times of stress.
[51] See, for example: Burton, I. and van Aalst, M. (2004). *Look Before you Leap: A Risk Management Approach for Incorporating Climate Change Adaptation into World Bank Operations*. Washington, D.C.: World Bank
[52] National governments can create an enabling environment that facilitates adaptation through such measures as capacity building, removal of barriers, knowledge sharing and financial support (Kartha *et al*. 2006).
[53] McGray et al. (2007).
[54] Song, S. (2010), African Undersea Cables "Many Possibilities." Retrieved December 2010, from: http://manypossibilities.net/african-undersea-cables/
[55] http://www.itu.int/ITU-D/ict/statistics/material/excel/2011/Mobile_Cellular_reg-11.xls. These figures need to be treated with some caution because many people subscribe to more than one network. On the other hand, it should be remembered that over 40% of sub-Saharan Africa's population is aged 15 and under.

Around 90% percent of the continent lives under the footprint of a mobile network that stimulated over $56-billion in private sector investments between 2004 and 2008.[56]

- Barely five years ago, the continent struggled with communication challenges as erratic and expensive very small aperture terminals (VSATs) and a single strand fibre cable along the west and southern coasts of Africa carried most of its international voice and data traffic. Today, new undersea cables which have been laid around the continent deliver better bandwidth, improving communications, enabling higher quality applications and increasingly contributing to the economic development of the continent as inland infrastructure is deployed to take advantage of this new capacity.

- Internet penetration in sub-Saharan Africa had reached 12.8 percent by the end of 2011, according to the ITU, but this rate remains low in comparison to the global average of over 30 percent.[57] Broadband penetration has also grown but the divide between African countries and the rest of the world is growing because of the very high rate of take-up in other regions. By the end of 2011, the ITU estimates that mobile broadband coverage in sub-Saharan Africa had reached 3.8 lines per 100 inhabitants, compared with over 50% in Europe. Fixed broadband coverage in Africa was still extremely low, at 0.2 lines per 100 inhabitants compared with around 25% in Europe.[58]

The impact of mobile phones on social behaviour and opportunity for African citizens is widely acknowledged. For the first time, during the last decade, the large majority of Africans have gained access to immediate interactive communications at a distance, extending the ease with which support can be sought and offered to individuals, families and communities, particularly by family members living at a distance or in the diaspora. Mobile telephony has extended the reach of information and, in some cases, financial services, with positive impacts on vulnerability. Mobile phones now provide the most widely used medium for internet access in Africa, a trend which will continue and accelerate in the short and medium term.

Despite these developments, the challenge of economic growth through increased penetration of broadband, undersea fibre infrastructure and mobile usage depends largely on the promulgation of appropriate policies and how they are aligned towards development. Inland national fibre backbone remains challenging in most countries and so are inter-country fibre links. Other challenges include right

[56] World Bank. (2010). Connecting Africa: ICT infrastructure across the continent. Retrieved December 2010 from: http://siteresources.worldbank.org/INFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/EnglishICT_flyer.pdf.
[57] http://www.itu.int/ITU-D/ict/statistics/material/excel/2011/Internet_users_reg-11.xls; *cf.* http://www.internetworldstats.com/stats.htm
[58] http://www.itu.int/ITU-D/ict/statistics/material/excel/2011/Mobile_bb_11.xls; http://www.itu.int/ITU-D/ict/statistics/material/excel/2011/Fixed_bb_11.xls

of way issues, persistent vandalism and ecological problems.[59] Equitable access to local markets for suppliers of high-level infrastructure such as broadband remains challenging in the face of regulation that often protects local markets. Policies to address these challenges should increase the benefits enabled by new infrastructure.

ICTs have a double-edged impact on sustainable development because of their complex relationship with economic and social structures, individual behaviour and the environment.[60] For example, the demand for components exerts pressure on extraction of raw materials and can fuel local conflicts, as has already been experienced in Africa.[61] The increasing energy demands of networks and devices, which lead to higher CO_2 emissions, are of growing concern (see section 1.5). But ICTs are also increasingly fundamental to the organization of economic production and exchange, to social dynamics and to the exchange of information and other resources. The ICT sector –including governments, private sector and other stakeholders – needs to maximize the opportunities that ICTs provide and minimize their negative impacts.[62] It is important to understand the complexity of the relationship between ICTs and socio-economic structures when considering their use in climate change adaptation.

1.5 ICTs and climate change[63]

There has been significant debate during the past five years about the relationship between ICTs and climate change. Although this is not solely concerned with adaptation, it is important to highlight the complex set of relationships which has been discussed in this literature, in particular the positive and negative impacts which they (can) have on carbon emissions.

The standard model for assessing the relationship between ICTs and climate change derives from work undertaken by the Forum for the Future.[64] This separates impacts of ICTs on climate change into three main categories of direct (first order), indirect (second order) and societal (third order) effects. All three involve some form of adaptation, though not necessarily as the term is used in the context of this study.

[59] AllAfrica.com. (2010). Nigeria: Phase Three Boss Roots for Aerial Optic Fibre. Retrieved December 2010 from: http://allafrica.com/stories/201008250417.html

[60] Souter, D., MacLean, D., Akoh, B., and Creech, H. (2010). ICTs, the Internet and Sustainable Development: Towards a new paradigm. Winnipeg: IISD. Retrieved December 2010 from: http://www.iisd.org/pdf/2010/icts_internet_sd_new_paradigm.pdf.

[61] Vetter T, (2008). Resource Wars and Information and Communication Technologies. Winnipeg: IISD. Retrieved December 2010 from: http://www.iisd.org/pdf/2008/com_resource_wars.pdf.

[62] Souter, D., MacLean, D., Akoh, B., and Creech, H. (2010). op. cit.

[63] The text of section 1.5 of the chapter is taken from forthcoming work on ICTs and sustainable development, by David Souter and Don MacLean, which is to be published by IISD (copyright of this section reserved to the authors and IISD). IISD work on adaptive policy-making can be found in *Designing Policies in a World of Uncertainty, Change and Surprise*, 2006, http://www.iisd.org/pdf/2006/climate_designing_policies.pdf).

[64] Forum for the Future (2002) 'The impact of ICT on sustainable development,' in *European Information Technology Observatory,* EITO 2002, 250-283.

Direct or first order effects represent the impact which ICTs themselves have on climate change, in particular the carbon emissions resulting from the production, use and disposal of communications equipment and services. These first order effects contribute significantly to emissions. Worldwide, they represent between 2% and 2.5% of total emissions, and are increasing at a compound annual growth rate of around 6%, faster than any other industrial sector.[65] This growth results from increased access to ICTs (a product of the extension of communications and power networks), increased use by more people of more devices which require some form of electric power, and increased use of data centres to deliver content to devices. It is therefore a direct and substantive negative result of the spread of ICTs and the capabilities with which they endow people, which (in other developmental contexts) are highly positive. As developing countries have historically been under-endowed with ICTs, the growth of ICT-derived emissions is faster in developing countries than industrial countries. The industry-led Global eSustainability Initiative has published estimates that the proportion of greenhouse gas emissions from the ICT sector which derive from developing countries other than China will rise from 17% of 0.53 gigatonnes of CO_2 equivalent in 2002 to 27% of 1.43 gigatonnes in 2020.[66] Although Africa is not by any means the largest contributor to this emissions growth, it will nevertheless play a significant part in it. Consciousness of the emissions impact of ICTs should underlay policymakers' thinking about climate change and adaptation.

The principal challenge for both policymakers and the ICT sector in relation to these first order effects is concerned with mitigation.[67] Increased access to and use of ICTs has many social and economic advantages and there is a general feeling that the resulting increased emissions have to be accommodated, as a result of these, within an overall framework which envisages large general reductions in emission levels. However, it is also recognised that a significant part of the mitigation burden should lie with the ICT sector. One example of this concerns the need for reductions in the energy required by communications devices and network use – an area in which standard-setting processes are significant and in which cloud computing will also have a growing impact. A second concerns the rate of churn of devices, which is currently very high – about two to three years in the case of mobile phones and personal computers. A slower rate of churn would be likely to result in lower carbon emissions. A third concerns the desirability of more energy-efficient behaviour by end-users, for example switching off devices when they are not in use rather than retaining them on standby. Although not adaptation in the sense of this report, these mitigation measures do require adaptation in sector management and user behaviour.

[65] The Climate Group (2008) *SMART 2020: Enabling the Low Carbon Economy in the Information Age*, Global e-Sustainability Initiative.
[66] *ibid.*
[67] For this and following paragraphs, see David Souter *et al.*, *ICTs, the Internet and Sustainable Development*, IISD, 2010.

Indirect or second order effects represent the impact which ICTs can have on the carbon emissions that result from other industrial sectors or from the behaviour of end-users as a result of those sectors and end-users adopting ICTs and using them (for example) to improve efficiency and productivity. The ICT sector estimates that very substantial reductions could be achieved in the emissions resulting from large-scale industrial processes and utilities as a result of the automation and computerisation of process management – for example the introduction of smart power grids (which improve the productivity of energy generation and transmission), more efficient transport logistics (also an issue for the regional integration and trade component of the Transformation Ready programme), better building design *etc*. Carbon savings are also anticipated from dematerialisation – *i.e*. the digitisation of some products and services, and changes in personal behaviour such as homeworking. Although also concerned with mitigation, these too are a kind of adaptation, in this case the adaptation of other economic/productive processes in ways that are made possible by ICTs.

Care needs to be taken in interpreting these second order effects. Firstly, unlike first order effects (which are effectively certain to occur as access and use increase), they are merely potential impacts. Whether their potential is fulfilled depends on decisions which must be taken by policymakers, industrial and utility managers who work outside the ICT sector. Secondly, unlike the first order effects described above (which result primarily from the extended reach of ICTs to individuals and communities), they will (if they arise) mostly result from decisions in a small number of very large organisations, which are almost all located in industrial countries and large emerging market countries such as China and India. For these reasons, these second order effects should not really be juxtaposed against the first order effects described above.

A further complication results from rebound effects, which may eliminate the gains resulting from apparent reductions in emissions. Rebound effects arise, for example, when behavioural changes resulting from indirect effects lead to increases in emissions which exceed the savings that previously occurred. An example which is often cited is increased power consumption resulting from lower energy prices that have been obtained through greater energy efficiency. Rebound effects are widespread in this context, and their likelihood needs to be considered by policymakers who are concerned with climate change, including adaptation and especially when modelling adaptation outcomes.

Societal or third order effects result from the large-scale changes in social and economic behaviour which occur as a result of widespread use of ICTs and the development of an information society. These might be described as the effects of society as a whole adapting to the increased presence of ICTs. These societal impacts are widespread, and affect the relationship between communities and climate change in a variety of ways. They are significant, for example, in the globalisation of trade and economic production; in changing patterns of social behaviour, such as the relationship between work and leisure, patterns of settlement, consumption and engagement within communities – whether those are local or geographically dispersed, family, professional or social in character. IISD examined the implications of

these changes for the understanding of sustainability in its 2010 report *ICTs, the Internet and Sustainable Development.*

An important element in policy development concerned with both sustainable development and the ICT sector is adaptiveness. The ICT sector changes so rapidly that policy prescriptions and business plans have a very short lifecycle. If they are to remain relevant, policies and business plans need continual reassessment and adjustment to changing technological and market circumstances. Climate change impacts are slower than ICT technology and market changes, but likewise require an understanding that policy prescriptions and business plans that were appropriate yesterday may be inappropriate today or tomorrow. The conjunction of these two sets of changes makes adaptive thinking particularly relevant to the use of ICTs in climate change adaptation. Approaches to adaptation which make use of ICTs will work differently in different contexts, both geographically and over time. Policymakers and stakeholders need to pay attention not just to the context of vulnerability but also to the ICT landscape, as it is and as it is evolving; not just to the ICT landscape but to the changing potential which it offers for engaging with communities and supporting their wider social, economic and environmental adaptive capacity. Today's best practice may not also be tomorrow's.

There is increasing recognition of the potential for ICTs to contribute to combatting climate change and growing appreciation of the role that they could play in reducing emissions of greenhouse gases (mitigation), and in preparing for and responding to unavoidable changes in the climate system (adaptation). A systematic approach is therefore needed to the application of ICTs to climate change adaptation. The following sections of this chapter describe the potential applications of ICTs within different adaptation frameworks, beginning with the reference to ICTs in the Cancun Adaptation Framework (adopted at the Cancun Adaptation Conference in 2010) but extending beyond that to a framework that examines ICTs within the broader context of adaptation and development. Further details and examples of applications at national, regional and global levels are presented in Chapters 2 and 3 of this report.

1.6 ICTs in the Cancun Adaptation Framework

The Cancun Adaptation Framework was adopted at the Cancun Adaptation Conference in 2010, part of the UN process in response to climate change. This Framework[68] provides space for countries to consider a range of ICT interventions. It invites all Parties (including both developed and developing countries) to enhance action on adaptation, *inter alia*, by: [emphasis added for this report]:

> […]
> *(d) Building resilience of socio-economic and ecological systems, including through economic diversification and sustainable management of natural resources;*

[68] http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=4

(e) Enhancing climate change related disaster risk reduction strategies, taking into consideration the Hyogo Framework for Action,2 where appropriate, early warning systems, risk assessment and management, and sharing and transfer mechanisms such as insurance, at the local, national, subregional and regional levels, as appropriate;

[…]

(g) Research, development, demonstration, diffusion, deployment and transfer of technologies, practices and processes, and capacity-building for adaptation, with a view to promoting access to technologies, in particular in developing country Parties;

(h) Strengthening data, information and knowledge systems, education and public awareness;

(i) Improving climate-related research and systematic observation for climate data collection, archiving, analysis and modelling in order to provide decision makers at the national and regional levels with improved climate-related data and information.

The Framework also refers to the importance of regional centres and networks for knowledge and information exchange. This has been referenced before in adaptation discussions and has been picked up in the Cancun Accords, which invite governments [emphasis added for this report]:

to strengthen and, where necessary, establish regional centres and networks, in particular in developing countries, with support from developed country Parties and relevant organizations, as appropriate, and to facilitate and enhance national and regional adaptation actions, in a manner that is country-driven, encourages cooperation and coordination between regional stakeholders and improves the flow of information between the Convention process and national and regional activities.

1.7 Adaptation and ICTs Framework

While there is an increasing number of examples of the use of ICTs in mitigation of climate change, ICT applications for adaptation are still relatively new. Alan Finlay (2011) conducted a survey of thirty ICT for Development (ICT4D) organizations to identify their level of engagement in climate change adaptation and their experiences to date. His survey concluded that adaptation is a new field of focus for these organizations and that more information is required on how it can be linked effectively with ICTs.[69]

To address this gap, a number of efforts have been made recently to link climate change adaptation and ICTs at the conceptual level and then to use this linkage to help guide processes for the development of adaptation tools and applications. One conceptual framework along these lines was created by Ospina and Heeks (2010) of the University of Manchester. It emphasizes ICTs' potential for reducing vulnerability to climate change by building resilience. Another approach, developed by Karanaisos

[69] Finlay (2011). *Climate Change as a Strategic Priority for ICT4D Organisations: Current Attitudes, Responses and Needs. New & Emergent ICTs and Climate Change in Developing Countries. Centre for Development Informatics* Institute for Development Policy and Management, University of Manchester, Manchester and IDRC, Ottawa, pp. 31.

(2010), focuses on identifying and delivering different types of information needed for effective adaptation to climate change. A third approach, developed by the Government of Samoa (2009), is a disaster risk management framework focused on reducing communities' overall risk of disaster losses, preparing for specific scenarios, and responding, managing and recovering from emergencies as they arise. Although differences exist between these frameworks, as described below, they distinguish two critical characteristics of climate change in responding to which ICTs can make a significant contribution:

- chronic impacts (*i.e*. long-term changes in climatic variables, seasonal shifts, migration of ecozones, *etc.*); and
- acute impacts (*i.e*. disaster management such as cyclones, flash floods, mudslides and dike breaches,).

According to the framework developed by Ospina and Heeks (2010), the ultimate goal of ICTs in adaptation should be to promote technologies that enable sustainable adaptation actions which ultimately help to build resilience. In their view, ICTs should provide information, tools and support to stakeholders that will enable them to address long-term climatic shifts or chronic impacts - rather than being used only to cope with immediate, short-term or acute impacts in ways that may not be sustainable over time. By way of example, using ICTs to enhance economic development in vulnerable areas through shrimp farming may increase income in the short-term and thus provide additional means to cope, but may also contribute to the loss of wetlands and mangroves that will increase vulnerability to cyclones over the longer term.[70] Of course, long-term unexpected impacts are an important challenge in all areas of development work: unanticipated negative consequences such as these may or may not arise, as may unanticipated positive consequences. Ospina and Heeks emphasize that current practices in the field of ICTs and development have experience in dealing with acute impacts, but less with chronic impacts, and that a stronger focus is therefore needed on addressing these longer-term processes. (An overview of their framework is presented in Appendix 2).

The second framework, developed by Karanasios (2011), agrees that for ICTs to be relevant to adaptation they need to address both acute and chronic impacts of climate change.[71] This framework is presented in Figure 2 of Appendix 2. It suggests that ICTs could support adaptation through actions in three areas:

- *Monitoring*: *i.e.* monitoring of weather and climatic patterns to indicate current, on-going and long-term changes, and to use this information to validate, particularly, downscaled climate projections. Monitoring should also help to predict the impacts of climate change, including

[70] Adger et al, 2005; adapted. Adger N., N. W. Arnell, E. L. Tompkins (2005) *Successful adaptation to climate change across scales.* Global Environmental Change 15: 77–86.
[71] Karanaisos S. (2011). *New and Emergent ICTs and Climate Change in Developing Countries*. Centre for Development Informatics Institute for Development Policy and Management, University of Manchester, Manchester and IDRC, Ottawa.

possible severe weather events, and to provide information for decision-making in various policy domains including industry, agriculture and the health sector.

- *Disasters*. Combining disaster management, early warning systems and communications could provide on-time information to policy-makers, professionals and the public on the possible severity of disaster events, including ways of dealing with them most effectively (in relation, *e.g.*, to evacuations, water and food supply locations, infrastructure, *etc.*).
- *Adaptation: i.e.* introducing new and revised approaches to environmental, health and resource management that may include climate change risk assessments at the local, regional and national levels, lessons for scaling interventions and practices developed at the local level, and ways of promoting resilience.

The third framework, developed by the Government of Samoa, suggests managing risks through risk identification, reduction and transfer; and emergency management through preparedness, emergency response, rehabilitation and recovery. (It is presented in Figure 3 of Appendix 2 to this report, section B.3). This framework also suggests that:

- The conjunction of hazard maps, such as GIS based data and strategic infrastructure mapping, with exposure to vulnerability of population and assets can be used to arrive at a true evaluation of disaster risks. However this has not occurred so far occurred in a way that makes full use of quantitative data.
- Risk transfer and insurance do not directly reduce expected losses, but can be used to encourage behaviour that favours mitigation.

While these three frameworks are relevant to addressing adaptation to climate change and ICTs, they also have shortcomings.

- The framework introduced by Ospina and Heeks is largely conceptual, and difficult to translate into practical guidance. For example, it focuses on resilience, the understanding of which remains a major challenge in the field of climate change adaptation, given the complexity embodied in the term.
- Karanasios' framework is more operational because it explicitly suggests what types of information are needed. However, it provides few details about measures, actions and tools that ICTs could support when it comes to adaptation.
- The Samoan framework focuses more on risk reduction, which is only one dimension of the potential for adaptation action.

In view of these shortcomings, IISD has sought to develop, for this report, a new framework for understanding the practical linkages between adaptation and ICTs in a more detailed manner. This

framework seeks specifically to reflect understanding of the links between climate risk[72] and sustainable development, the uncertainties in climate change projections[73] and their likely impacts, and the possibility that practical application of ICTs in supporting adaptation may differ little from their more general application for development.

With respect to the first of these criteria, a focus on understanding the links between climate risk and sustainable development requires an understanding of the need for ICTs to reduce vulnerability to both natural climate variability and human-induced climate change. This focus is necessary in part because of the challenge of determining whether a specific climate event or trend is due to human-induced climate change or the result of normal climate variability.[74] More importantly, from the perspective of individual farmers, government planners, businesses and others coping with various climatic conditions, it is the inherent risk associated with a climatic event or trends—whether caused by climate variability and/or climate change—that must be managed. Moreover, the practical measures taken to reduce the risks associated with climate change, whether enabled through the use of ICTs or not, typically differ little from those currently being used to manage climate variability.

In relation to the third criterion, recognition that there may be little practical difference between the application of ICTs for adaptation and for development can be illustrated by consideration of the application of geographical information systems (GIS). These systems may be used to inform policymakers of non-climate-related data such as the location of mineral deposits, as well as areas that may be potentially affected by floods, landslides and other extreme weather events. What makes ICT tools and applications supportive of adaptation is not their inherent qualities, but the degree to which their application is used strategically to reduce climate risks—either deliberately (based on climate risk analysis) or serendipitously (through development interventions that contribute to building adaptive capacity). It is the application of a climate risk "lens" when assessing current applications of ICTs in different sectors that provides an opportunity to identify those that have the greatest promise for addressing climate variability and climate change today and in the future.

[72] Climate risk refers to the probability of harmful consequences or expected loss (e.g., death, injury, loss of livelihoods, reduced economic productivity, environmental damage) resulting from interactions between climate hazards and vulnerable conditions in the context of climate variability and change (adapted from United Nations International Strategy for Disaster Reduction (2009). *2009 UNISDR Terminology on Disaster Risk Reductio*n. Geneva: UNISDR. Retrieved from: http://unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf).

[73] Uncertainty will remain a component of climate change projection, but it should not be used as an excuse for inaction and inappropriately interpreted as a case of ''no knowledge.'' Scientists need to become better at quantifying and communicating uncertainties, whereas decision makers need to learn how to work with fuzzy knowledge, acknowledging that it is better than no knowledge at all (Howden et al, 2007). Howden M. S., J. F. Soussana, F. N. Tubiello, N. Chhetri, M. Dunlop. and H. Meinke (2007) *Adapting agriculture to climate change.* PNAS 104 (50): 19691–19696.

[74] It should be recognized, however, that the number of examples of extreme climate events that fall outside of historical experience is increasing. These events may be directly attributed to climate change. See, for example: Hansen, J., Sato, M., and Ruedy, R. (2011). Climate Variability and Climate Change: The new climate dice. Retrieved from: http://www.columbia.edu/~jeh1/mailings/2011/20111110_NewClimateDice.pdf

With these considerations in mind, IISD's new framework has been developed by drawing on the concept of the "adaptation continuum" conceived by McGray et al. (2007).[75] Reflecting an understanding of the links between adaptation and development, this continuum identifies adaptation efforts ranging from activities that address the general, underlying determinants of adaptive capacity (*e.g*. access to economic resources, technology, information, infrastructure and good governance), which are highly coincident with traditional development practice, to activities that respond to a specific, known climate change-related impact that is outside historical experience.[76] The new framework recognizes that adaptation requires policymakers and practitioners to address both current vulnerabilities and longer-term climate threats. Specifically, it identifies four types of activity that fall along this continuum of adaptation (adapted from McGray et al., 2007; see box 1-2):[77]

- **Addressing the drivers of vulnerability:** The primary focus in this area is on reducing the major underlying causes of vulnerability, including improvements in the health of people, infrastructure, education and poverty reduction. Very little attention is given to addressing specific climate related stresses and shocks—whether due to climate variability or climate change. The emphasis is on contexts in which people struggle to cope with current socio-economic challenges.

- **Building the response capacity of local and regional systems and communities:** Activities in this area focus on ensuring that communities and systems have access to the resources they need to deploy when impacts are experienced that result from climate variability and climate change. For example, communities should have access to new, flexible technologies, management strategies, insurance schemes and economic incentives that allow for adjustments based on impacts that may occur currently and/or in the future. Actions in this context also include the strengthening of institutions and cooperation to increase effectiveness.

- **Reducing and managing risks related to climate variability and climate change:** Climate information is incorporated in decision-making to reduce the negative effects of climatic factors on resources and livelihoods, whether these are due to climate variability or climate change. Examples of such actions include the promotion of pest, disease and weed management, revisions to codes and standards for infrastructure, the introduction of new crops, and transition planning (such as the development of alternative livelihoods or financial and technical contingency plans) in areas where agriculture will have a limited role.

[75] McGray H., A. Hammill, and R. Bradley (2007). *Weathering the Storm Options for Framing Adaptation and Development.* Washington DC: World Resources Institute.
[76] Parry, J., J. Drexhage and F.G. Lebrun (2008). Adaptation in a Post-2012 Climate Regime. In J. Drexhage, D. Murphy and J. Gleeson, Ed. *A Way Forward: Canadian perspectives on post-2012 climate policy.* (pp. 67-134), Winnipeg: International Institute for Sustainable Development.
[77] McGray et al. (2007).

- **Confronting climate change:** Actions taken in this area respond almost exclusively to impacts known to be caused by climate change. For example, actions taken in response to the threat of rising sea levels might include building dykes, relocating populations from areas exposed to potential extended flooding, and building flood-proof roads. Other possible adaptation measures might include expanding health programs concerned with malaria and other diseases that are projected to become prevalent in new areas because of the increased ability of vectors (*e.g.* mosquitoes) to survive in new locations (*e.g*. higher altitudes) as a result of changing climate.

Box 1-2: A continuum of adaptation activities (adapted from McGray et al. 2007)

1. Addressing the Drivers of Vulnerability	2. Building Response Capacity	3. Managing Climate Risk	4. Confronting Climate Change
Activities reduce poverty and address other fundamental shortages of capability that make people vulnerable to harm. Very little attention is given to specific climate change impacts but actions can increase resilience to climate stresses and shocks.	These capacity building actions lay the foundation for more targeted adaptation actions and include institution-building and technology sharing efforts familiar to the development community.	Climate information is incorporated into decisions to reduce the negative effects of climatic factors—due to either variability or climate change—on resources and livelihoods.	Actions taken respond almost exclusively to impacts known to be caused by climate change.
Examples: micro-credit schemes; immunization programs	Examples: improving communications infrastructure; training in GIS technology	Examples: introduction of drought-resistant crops; emergency response systems	Examples: reducing potential for a glacial lake outburst flood; building sea walls
Vulnerability Focus			Impacts Focus

Source: Parry, J-E., Drexhage, J. and Gagnon-Lebrun, F. (2008)[78]

Further illustration of the adaptation action identified as necessary by countries in relation to these different components can be found in Appendix 3.

A review and scan of the use of ICTs in climate change adaptation applications, was undertaken by IISD to help develop understanding of the types of tools that may be appropriate for supporting adaptation

[78] Parry, J-E., Drexhage, J. and Gagnon-Lebrun, F. (2008) Adaptation in a Post-2012 Climate Regime. In J. Drexhage, D. Murphy and J. Gleeson (Eds.), A Way Forward: Canadian perspectives on post-2012 climate policy. Winnipeg: IISD.

action along this continuum. This review revealed that experiences and tools have been categorized in three main ways:

- sectorally, dealing with adaptation issues in practitioner domains such as education, health or agriculture;
- by implementation scale, which ranges from individual to national, regional or even global reach (this last in the case of internet applications or satellite systems); and
- by the physical size of application resources, ranging from mobile handheld devices to elaborate and complex implementations such as earth stations, large-scale GIS and remote sensing applications.

Appropriate categorization of these tools is therefore not a simple exercise. The dynamic and portable nature of ICTs implies that one specific tool might be applied in different ways in many contexts, situations or environments. Based on these considerations, and given the particular interest of the African Development Bank in planning for technology investments, IISD concluded that it would be most useful to examine applications in a spectrum ranging from smaller implementations such as mobile phones and GPS navigation systems to very large deployments such as satellite systems and meteorological stations.

There have been various applications of ICTs, used directly or serendipitously, within the different activity ranges already mentioned, particularly under the framework of "ICT for Development" initiatives which have been supported in the past decade by many government departments, donor organizations and international financial institutions. Such applications include, for example, the development of multimedia telecenters; the provision of community platforms for dialogue, information and knowledge sharing through the use of radios and televisions; traditional knowledge and content creation housed in online databases; the development of geographic information systems and their introduction to decision making; and the proliferation of access to rural and urban areas. However, some policy considerations need to be addressed in order to advance the positive outcomes that have resulted from these interventions. One example would be the establishment of mechanisms for access to environmental data generated by global geo-satellites, early warning systems and remote sensing equipment, which can enhance decision making abilities and contribute to disaster relief. Other policy considerations include:

- Support for the acquisition and deployment of ground stations and intelligent environmental measuring equipment that can be positioned strategically to gather weather and environmental data, complementing those generated from geo-satellites.
- Development and application of systems for meteorological purposes, comparable with the deployments of geographic information and modelling systems that have been introduced in other areas such as agriculture, health and coastal protection.

- Implementation of capacity-building, training and education strategies that are needed to maximize the potential of existing and future meteorological systems.
- Development of communication strategies, public information, outreach and awareness campaigns that could further contribute to raising awareness, communicating climate change information and relaying potential mechanisms for adaptation. Partnerships in private and public sectors are required to distribute these messages more widely.
- Leveraging the gains that have been made in access to internet infrastructure and the growth of mobile phones, handheld devices, mobile internet, and broadband penetration, and using these for: a) decentralized distribution of climate data to communities where they can assist in adaptation; and b) uploading data generated by local and community based research to complement existing meteorological data.
- Continuing to advance access and growth in mobile, broadband, and the internet, and to develop principles in support of affordability that could contribute to the implementation and growth of adaptation strategies.

Table 1-2 highlights these ICT categorizations, the policy considerations that could be applied within them, and their relevance to climate change adaptation.

Table 1-2: ICT applications and relevance to climate change adaptation

	ICT tool type	Policy considerations	Relevance to climate change adaptation
Large scale implementations	• Early warning Systems • Weather Management • MET Systems • Satellite and Remote Sensing Systems	• Open data	The use of ICTs for monitoring and measuring impacts of climate change, assessing its effects, controlling interactions with the environment and helping in disaster relief (*e.g*. the 'Internet of Things') (MacLean, 2008; ITU, 2008).
	• Smart Systems • Sensor Networks	• Infrastructure deployment	Extensive data-gathering through weather and environmental sensors connected to telecommunications networks (ITU, 2008).
	• Geographic Information Systems (GIS) • Global Positioning Systems GPS) • Modelling	• Capacity building, training, and education	Systems and tools for specific sectors (*e.g*. agriculture, forestry, human health, coastal protection, agriculture, water management, forestry, *etc*. The range of systems and tools which belongs to this category is extremely wide, covering (or at least trying to cover) all the information-based issues of such a cross-cutting phenomenon. (Sala, n.d).[1]
Small scale implementations	• Knowledge Management • Information Sharing Systems • Planning • Decision support tools	• Communication strategies • Public information, outreach and awareness • Partnerships	Importance of ICTs in raising awareness and communicating information about climate change impacts, related vulnerabilities and possible ways of adaptation (MacLean, 2010).[1]
	• Mobile Phone Applications • General Packet Radio Systems (GPRS) • Telemetry	• Access and Affordability of Access	The use of the range of established low-tech ICTs (radio, television, mobile phone, etc.) and convergence with new ICTs show the contextual compatibility of these technologies to vulnerable communities. Mobile phones and advances in mobile technology are likely to continue to play a large role in climate change adaptation (Karanasios, 2011).

Also for this report, IISD has developed a framework which brings together the continuum needed to address adaptation to climate change with the types of ICT tools that might be used to support adaptation efforts. This framework provides an effective vehicle for considering a broad range of ICTs—from small-scale implementations such as mobile phone applications to large-scale ICTs such as sensor networks and national scale early warning systems—to address different aspects of adaptation to climate change and to address the policy issues in these continua. This framework, which is presented in Table 1-3, informs the remainder of this report.

Table 1-3: A framework for examining ICT tools and adaptation to climate change

<table>
<tr><th colspan="3"></th><th>Addressing Drivers of Vulnerability</th><th>Building Response Capacity</th><th>Managing Climate Risk</th><th>Confronting Climate Change</th></tr>
<tr><td colspan="2">Tool & Application Categories /Continuum of Adaptation Activities</td><td>Policy Considerations</td><td rowspan="2">Examples: Micro-credit schemes; immunization programs</td><td rowspan="2">Examples: Improving communications infrastructure; training in GIS technology</td><td rowspan="2">Examples: Introduction of drought-resistant crops; emergency response systems</td><td rowspan="2">Examples: Reducing potential for glacial lake outburst flood; building sea walls</td></tr>
<tr><td>Scale</td><td>Examples:</td><td></td></tr>
<tr><td rowspan="3">↑

Large scale imple-mentations of ICTs</td><td>• Early warning Systems
• Weather Management
• MET Systems
• Satellite and Remote Sensing Systems</td><td>• Open Data Policies
• Acquisition</td><td></td><td></td><td></td><td></td></tr>
<tr><td>• Smart Systems
• Sensor Networks</td><td>• Infrastructure deployment</td><td></td><td></td><td></td><td></td></tr>
<tr><td>• Geographic Information Systems
• Global Positioning Systems
• Modelling</td><td>• Capacity building, training, and education</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Small scale imple-mentations of ICTs

↓</td><td>• Knowledge Management Systems
• Information Sharing Systems
• Planning Decision tools</td><td>• Communication strategies
• Public information, outreach and awareness
• Partnerships</td><td></td><td></td><td></td><td></td></tr>
<tr><td>• Mobile Phone Applications
• General Packet Radio Systems (GPRS)</td><td>• Access and Affordability of Access</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2"></td><td></td><td colspan="2">← Vulnerability Focus</td><td colspan="2">Impact Focus →</td></tr>
</table>

Chapter 2 - Landscape Analysis of Climate Change Adaptation Action in Africa

As has been highlighted in Chapter 1, African countries are particularly vulnerable to the impact of climate change because they have more limited capacity to adapt. Across the continent, countries have limited financial, institutional and human resources, are highly dependent on ecosystem-based economic and livelihood activities (*e.g*. agriculture, fishing, herding), and are affected by other environmental stress factors such as land degradation that increase vulnerability to the impact of climate change. As a result, climate change has real potential to limit, and even reverse, the economic and social progress that is being made by many developing countries.[79] A number of initiatives are underway in Africa that respond to this threat and seek to increase the adaptation capacity of communities, sectors and countries.

This chapter presents:

- an overview of adaptation-related policy initiatives across Africa at the intergovernmental and national level, drawing attention to those that specifically include reference to ICTs; and
- a sampling of some of the adaptation projects and programs which are underway that respond to needs and priorities identified by national governments, highlighting those that include ICT-enabled components.

2.1 Adaptation policies and strategies in Africa

Across Africa, governments have completed analyses of their vulnerability to the impacts of climate change and identified priority actions that need to be taken to reduce that vulnerability. In addition, some have begun to develop specific plans and strategies for meeting the challenges of climate change, including adaptation. The establishment of these plans, along with efforts to integrate adaptation considerations into national level policies and programming, is critical. National governments are responsible for setting legislation and regulations that may enhance or constrain the capacity of other actors to adapt. They establish the framework within which lower levels of government operate; coordinate sectoral policies in areas such as disaster reduction, water, agriculture and health; and manage trans-boundary resources and international cooperation efforts.[80] This first section of Chapter 2

[79] See, for example: (1) African Development Bank [AfDB] et al (2003). *Poverty and climate change: Reducing the vulnerability of the poor through adaptation*; and (2) World Bank (2010). *World Development Report 2010: Development in a changing climate*. Washington D.C.: World Bank.

[80] OECD (2009). Integrating Climate Change Adaptation at the National Level. In: *Policy Guidance on Integrating Climate Change Adaptation into Development Cooperation*. Joint High-Level Meeting of the OECD Development Assistance Committee and the Environment Policy Committee.

provides an overview of these initiatives and concludes with some observations regarding the degree to which ICTs have been explicitly incorporated into these policies, plans and strategies.

2.1.1 Continent-wide action

Through a variety of inter-governmental actions, the governments of Africa have come together to express their needs with respect to adaptation to climate change, and to identify strategies for addressing these requirements. Their actions are reflected in programs of the African Union (including the New Partnership for Africa's Development, NEPAD[81]), pan-African ministerial bodies, intergovernmental organizations, and transboundary efforts to manage water resources. The following paragraphs provide an overview of the governance structure currently in place at continental level in Africa for addressing climate change adaptation.

The African Union (AU)[82] is the core intergovernmental institution for addressing climate change adaptation at continental level; the issue is being integrated with its overall development focus for the continent which was agreed in 2007 at the 8th Ordinary Session of the AU, African Heads of State and Government.[83] Since then, African governments have highlighted the need to take coordinated action for adaptation through the adoption of other declarations and decisions. The NEPAD Action Plan for 2010-2015,[84] for instance, identifies a number of priority programs in environment and climate change adaptation. These include the Climate for Development in Africa Initiative and the Green Wall for the Sahara and Sahel Initiative, both of which are described in section 2.2 below.

Other high-level governance mechanisms that provide political and technical leadership to address climate change adaptation include pan-African ministerial bodies, such as the African Ministerial Conference on the Environment (AMCEN), the African Ministerial Council on Water (AMCOW), the African Ministerial Conference on Meteorology (AMCOMET), and the African Ministers Council on Science and Technology (AMCOST). In 2009, the Special Session on climate change of the AMCEN adopted the *Nairobi Declaration on the African Process for Combating Climate Change*, which stressed that "Africa's priorities are to implement climate change programs with a focus on adaptation" and called for steps to ensure "that climate change adaptation imperatives are aligned more closely throughout regions and countries."[85] More recently, in June 2010, the *Bamako Declaration on the*

[81] NEPAD is both a vision and a policy framework for Africa that provides guidance for coordinating actions at regional and continental levels (NEPAD, http://www.nepad.org/).
[82] The AU regroups 53 African member states (all African States except Morocco) and was created in 2002 to foster political and economic integration at continental level.
[83] http://www.uneca.org/eca_programmes/sdd/events/climate/FACT-SHEET-AUsummit.pdf
[84] AU/NEPAD. (2009). *Africa Action Plan 2010-2015: Advancing Regional and Continental Integration in Africa. Sectors*. NEPAD.
[85] AMCEN (2009). "Nairobi Declaration on the African Process for Combating Climate Change" in *Report of the ministerial segment of the special session on climate change of the African Ministerial Conference on the Environment, Special session on*

Environment for Sustainable Development was adopted by African environment ministers as a road map for addressing issues including loss of biodiversity and access to benefit-sharing as well as desertification and climate change challenges in Africa.[86] In August 2010, the consultative meeting on climate change of the AMCEN approved a *Communication Strategy on Climate Change* and a *Comprehensive Framework of African Climate Change Programmes* to help African stakeholders to access relevant information on climate change and to foster coordination of their activities.[87]

The actions of the AU and some pan-African ministerial bodies on adaptation have been reinforced at a regional level by the Regional Economic Communities (RECs),[88] which form building blocks for the AU's economic strategy and contribute to the implementation of NEPAD, and by a number of river basin associations that have been set up on the continent. Policy agreements on adaptation which have been adopted by RECs such as:

- The East African Community (EAC) developed a climate change policy in 2010. Its overall objectives are to guide the preparation and implementation of collective measures, to harmonize and coordinate implementation of climate change actions, and to identify priority action areas in addressing climate change.[89]

- The Economic Community of West African States (ECOWAS) has initiated at least three recent policy initiatives on climate change adaptation:[90] a Framework of Strategic Guidelines on the Reduction of Vulnerability and Adaptability to Climate Change in West Africa,[91] a Regional West Africa Climate Change Adaptation Strategy focusing on the Niger and Senegal River Basins with the support of the World Bank, IUCN, CILSS, and Global Water Program, and the Lomé

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climate change, Ministerial segment, Nairobi, 29 May 2009: 1,2. Retrieved from http://www.unep.org/roa/Amcen/Amcen_Events/3rd_ss/Docs/nairobi-Decration-2009.pdf

[86] http://www.unep.org/roa/amcen/amcen_events/13th_Session/Docs/AMCEN-13-CRP-2_ENG.pdf

[87] AMCEN and UNEP (2010). *Report of the consultative meeting on the draft communications strategy on climate change and the comprehensive framework of African climate change programmes*, Nairobi, 23–26 August 2010.

[88] The eight Regional Economic Communities (RECs) of Africa are: (1) African Economic Community; (2) the East Africa Community; (3) the Economic Community of West African States; (4) The Common Market for Eastern and Southern Africa; (5) The Southern Africa Development Community; (6) the Intergovernmental Authority on Development; (7) the Community of Sahel-Saharan States; and (8) Economic Community of Central African States.

[89] EAC Secretariat. (2010). *EAC Climate Change Policy*. May 2010.

[90] Niasse, M. (2007). *Eléments de stratégie régionale d'adaptation au changement climatique basé sur l'approche de partage des risques - Afrique de l'Ouest.* Programme Adaptation au Changement Climatique en Afrique.

[91] The framework has three major objectives: (1) to ensure scientific and technical capacity building for the region on the reduction of vulnerability to climate change;, (2) to promote the integration of climate change components in the elaboration of development policies, strategies, programs and projects at regional and national levels; and (3) to develop and implement regional and national programs and projects on adaptation to climate change.

Declaration on Climate Change and Protection of Civilians in West Africa[92] which resulted from a Regional Conference on Protection Challenges to Climate Change in the region.

- The Common Market for Eastern and Southern Africa (COMESA) has developed a comprehensive Climate Change Initiative with the goal of "achieving economic prosperity and climate change protection."[93] So far, COMESA seems to have focused primarily on mitigation. However, it is engaged in a new 45 million euro Programme on Climate Change Adaptation and Mitigation in the Eastern and Southern African Region, which has the particular aim of increasing investments in climate-resilient and carbon-efficient agriculture, forestry, land use and energy practices across the COMESA-EAC-SADC member states.[94]

- The EAC, ECOWAS and COMESA have been among the most effective RECs in Africa. Others have been hampered by regional conflicts and other political and economic challenges. One of these, the Intergovernmental Authority on Development (IGAD), was established in 1996 by the AU to respond to the challenges caused by droughts in the Greater Horn of Africa. It has a disaster risk management programme supported by its Climate Prediction and Applications Centre (ICPAC). This Center seeks to coordinate work on climate risk reduction issues in the region.[95]

Other examples of intergovernmental organizations working toward climate change adaptation include African water basin associations such as the Nile Basin Initiative and the Niger Basin Authority.

The Nile Basin Initiative (NBI) is a partnership of the ten Nile riparian states which was set up to improve regional management of the Nile Basin.[96] Adaptation to climate change is not one of the stated objectives of the Initiative, but a project was launched in March 2010 in partnership with the United Nations Environment Programme (UNEP) on "Adapting to Climate Change Induced Water Stress in the Nile River Basin."[97] This project aims to minimize the threat which water stress poses to states in its

[92] Its objective is to "promote and establish adaptation mechanisms which take into consideration regional cooperation, national expertise and knowledge in order to formulate the necessary multi-sectorial answers to efficiently face the global challenge [of climate change] at the sub-regional level." (ECOWAS, Republic of Togo and United Nations 2009).
[93] COMESA, http://www.comesa.int
[94] COMESA, http://www.comesa.int/lang-en/component/content/article/34-general-news/603-eucomesa-sign-three-programmes-worthy-over-55-million-to-support-regional-integration-and-comesas-strategic-plan . These three RECs – COMESA, EAC and SADC have signed a Tripartite Agreement which seeks to coordinate their work across their 26 member states.
[95] International Authority on Development [IGAD]. (no date). Regional perspective in disaster risk reduction. IGAD report.
[96] The Nile Basin Council of Ministers of Water Affairs (NILE-COM) is the highest decision making organ of the Nile Basin Initiative and it meets annually to deliberate on policy related issues of the NBI.
[97] Funded by the Swedish International Development Agency, the initial phase of this project is expected to be between November 2009 and October 2012.

region through conflict and disaster, through knowledge-based policy intervention, technology transfer and infrastructure investment in selected "hotspots."[98]

The Niger Basin Authority (ABN) is an intergovernmental organization comprised of nine West African countries which seeks to foster co-operation in managing and developing the resources of the Niger river system. The ABN has developed an Action Plan for the Sustainable Development of the Niger Basin (2007). This highlights four priority areas: conservation of the basin's ecosystems, development of socio-economic infrastructures, capacity-building, and stakeholder involvement. Although the Plan makes little or no direct reference to climate change adaptation, ABN intends to develop and implement a regional strategy for adaptation which will include a review of all the National Adaptation Programmes of Action (NAPAs, see below) within the region.[99]

RECs are becoming more involved directly and indirectly in actions that support climate change adaptation. There is general movement towards the development of specific policy, guidelines strategies and/or comprehensive programs that integrate climate change adaptation aspects. However, the level of political engagement (and potentially of human and financial resources) varies among the different RECs.

Since 1997, the declarations and decisions of the AU, together with the actions of some pan-African ministerial bodies, and especially AMCEN, have contributed to raising climate change adaptation as a priority for sustainable development on the continent. African governments have shown increasing awareness of the issue and have called for:

(1) the mainstreaming of climate change adaptation in policies, programmes and activities at all levels;
(2) the implementation of climate change adaptation actions;
(3) the promotion of a programmatic approach to adaptation interventions (*i.e*. coordinated mobilization); and
(4) capacity-building for adaptation.

At the regional level, inter-governmental organizations are seeking to strengthen the actions of the AU on climate change adaptation. The EAC and ECOWAS have been particularly active in integrating climate change adaptation at the policy level through the formulation of policy and regional guidelines and/or strategies. Some African water basin organizations are also starting to implement new climate change

[98] Sources: (1) Mumba, M. and Muragori, B. (Eds). (2010). *Inception Workshop for the SIDA-funded Nile Basin project: Adapting to Climate Change Induced Water Stress in the Nile River Basin, Workshop proceedings, 25 – 26 March 2010, Nairobi, Kenya*. UNEP; and (2) UNEP web site, http://www.unep.org/climatechange/adaptation/EcosystemBasedAdaptation/NileRiverBasin/tabid/29584/Default.aspx

[99] Personal communication, ABN representative, December 2010; and ABB (2007).

adaptation projects (*e.g*. NBI) or planning to integrate adaptation into their strategies (*e.g*. ABN). However, despite this process, the level of engagement on climate change adaptation varies. Action is still in the early stage of mobilization and the concrete implementation of policy initiatives has yet to be experienced and evaluated. The different organizations involved face various challenges, including a lack of funding and limited human resource capacity, which limit program implementation.[100] As in other areas of development policy, and as at national level, it is important that international agencies see the development of policies and strategies as the starting point of action to tackle climate change adaptation, rather than the end-point of their interventions.

2.1.2 National-level policy efforts

Almost all African countries have ratified the United Nations Framework Convention on Climate Change (UNFCCC), and have therefore committed themselves to taking actions that should reduce their vulnerability to the adverse effects of climate change. As a step towards this goal, governments are researching and reporting on their vulnerability to the impacts of climate change, identifying priority actions that could be taken to reduce this vulnerability, and initiating the development of policies, plans and strategies to guide this work. As with international interventions, however, there is a risk that policy and strategies may not be translated effectively into practical implementation of projects and activities.

A first step along the path of climate policy development for the governments of many African countries is the preparation of a National Communication for submission to the UNFCCC. These national strategy documents should outline specific national development priorities, objectives and circumstances[101] - including a section on the country's vulnerability to climate variability and climate change - and identify adaptation action to address these vulnerabilities. Most African countries have submitted their National Communications.[102] Eleven have now submitted a second National Communication.[103]

In addition to the National Communications, the governments of 34 Least Developed Countries (LDCs) in Africa[104] are eligible to submit National Adaptation Programs of Action (NAPAs) to the UNFCCC in recognition of their limited capacity to lessen their vulnerability to climate variability and climate

[100] The AU, for example, is currently facing budget constraints and the 16th AU Summit, held in January 2011, highlighted the need to find alternative sources of funding for the development of its programs. The AU Summit approved a budget of 256.75 million USD for 2011[100] (AU, Decisions of the Executive Council, January 2011). Funding sources for the AU (including the NEPAD) mainly come from contributions of AU states and support from development partners.
[101] UNFCCC, http://unfccc.int/2860.php
[102] African countries that have not yet submitted a National Communication are Angola, Equatorial Guinea, Liberia, Libya and Somalia.
[103] These countries were as of September 2011: Algeria, Burundi, Côte d'Ivoire, Democratic Republic of the Congo, Egypt, Madagascar, Mauritania, Morocco, Niger, Republic of the Congo and Senegal.
[104] This number includes Cape Verde, which has subsequently graduated from the least developed countries group.

change.[105] Through NAPAs, these governments can identify their urgent and immediate adaptation needs, and propose priority projects that may be funded through the UNFCCC's Least Developed Countries Fund.[106] Thirty-one African LDCs have submitted NAPAs,[107] and funding from the Least Developed Countries Fund for NAPA projects has been received by 32 countries.[108]

In addition to these documents, several countries have initiated or completed the development of national adaptation plans and/or strategies. The government of Kenya, for example, has agreed a National Climate Change Response Strategy that includes adaptation among its objectives and that has initiated the development of an adaptation plan. The government of South Africa is developing a National Climate Change Response Policy that will serve as the country's comprehensive adaptation strategy. It is expected to build on South Africa's earlier National Climate Change Response Strategy published in 2004.[109] São Tomé and Príncipe has developed a National Strategy for Climate Change Adaptation that addresses concerns related to its health, economy, water, agriculture, fisheries and coastal zone management sectors.

Some efforts are being made to integrate adaptation into national level policies and plans in other countries. Examples of countries whose governments have addressed climate change to some degree include the following:

- Uganda – where adaptation is incorporated into the Vision 2025 objectives, the Five-Year National Development Plan and a draft National Policy for Disaster Preparedness and Management.
- Benin – whose Integrated Water Resource Action Plan works with farmers to adapt their practices to changing rainfall patterns;
- Mali – whose Environmental Information, Education and Communication Program (part of its Environmental Plan of Action) aims to raise awareness on and assess impacts of climate change; and
- Niger – whose Nationale des Capacités à Renforcer is an inventory and analysis of national initiatives concerned with biodiversity, climate change and soil degradation.

[105] UNFCC, http://unfccc.int/2860.php

[106] Through their NAPAs, LCD countries can apply to the LCD Fund, which is managed by the GEF. This leads to the implementation of projects under the GEF project cycle. See http://unfccc.int/cooperation_support/least_developed_countries_portal/ldc_work_programme_and_napa/items/4722.php

[107] The exceptions are Angola, whose NAPA is in the final stages of development, Equatorial Guinea and Somalia (GEF, 2011).

[108] Global Environment Facility [GEF] (2011). Progress Report on the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF). GEF/LDCF.SCCF.10/Inf.3/Rev.1. Accessed from http://www.thegef.org/gef/sites/thegef.org/files/documents/Progress%20Report.rev1_.pdf

[109] World Resources Institute (2010). "Moving Forward on Climate Adaptation in South Africa." Accessible here: http://www.wri.org/stories/2009/09/moving-forward-climate-adaptation-south-africa

2.1.3 ICTs in national polices and strategies

Through their various reports, policies and statements, African governments have articulated a desire for greater collaboration, capacity-building and sharing of information between countries. They have also identified priority sectors for adaptation, which are listed in Table 2- 2-1. Across the continent as a whole, governments have identified water resources, health, agriculture, forestry and coastal zone management as being priority sectors for action. Regional variations are apparent, with pastoralism important in East and West Africa, where there are many nomadic and semi-nomadic communities. Fisheries are of concern in West, Central and Southern Africa. Many countries in West, East and Southern Africa have also identified a desire to improve their meteorological and forecasting capacity and to strengthen their early warning and disaster risk reduction systems.

Table 2-1: A brief assessment of regional priority areas

Regional Priority Areas/Region	West Africa	East Africa	Southern Africa	Central Africa	North Africa
Agriculture	✓	✓	✓	✓	✓
Pastoralism	✓	✓			
Fisheries	✓		✓	✓	
Forestry	✓	✓	✓	✓	✓
Sustainable Land Management		✓			
Water Resources	✓	✓	✓	✓	✓
Coastal Zones/Infrastructure	✓		✓	✓	✓
Health	✓	✓	✓	✓	✓
Meteorological Services and Research; Climate/Weather Forecasting	✓	✓	✓		
Early Warning and Risk Reduction		✓	✓		
Nature / Biodiversity			✓	✓	
Tourism			✓		✓
Governance			✓		
Infrastructure					✓

Governments have made some references to ICTs in National Communications, NAPAs and other documents which establish these sectoral priorities, though these references are rather few and limited. The use of ICTs is suggested for tasks such as the collection and dissemination of agro-meteorological information, monitoring for flood projection, and planning for and tracking of changes in the distribution of diseases such as malaria and meningitis. Examples of ways in which ICTs are linked to activities identified in the policies and plans of African countries – and how they relate to the framework developed in Chapter 1 – are summarized in Table 2-2.[110]

[110] IISD, *Adaptation Review: West Africa, East Africa, North Africa, South Africa, Central Africa.*

Table 2-2: Overview of the priorities and specific activities with focus on ICT in adaptation action in Africa

Country	Specific role in the adaptation action	Details on activities with relevance to ICT	Areas of focus
Building response capacity			
Burkina Faso	Security of agricultural production through the use of appropriate technology packages in the South West and East of the country	Strengthening of adaptive capacity and well-being of people through the recovery of degraded land and sustainable productive, diversified, and profitable agriculture by using capacity-building and knowledge-sharing (technology transfer).	Agriculture; food security
Guinea	Early warning systems	Development of an early warning system for securing agricultural productivity by modeling and information generation.	Early warning systems
Mali	The NAPA includes two specific projects that are relevant for ICT on hydrologic and health information systems	Regarding hydrological information systems, a study will examine the contribution of small experimental ponds to food sufficiency and resource protection. On health information systems a study will develop an information system to understand and monitor climate-related illnesses.	Agriculture; water resources; health
Reducing and managing risks			
Benin	Research and transfer of technology including ICTs	Usage of ICTs in disaster preparedness; pest and disease forecast and control.	Agriculture; food security
Namibia	Strategy stresses the importance of integrating information on climate change in existing policies and frameworks, and the use of ICTs in agriculture and disaster preparedness	In agriculture the project looks at improving information dissemination around the effects of climate change, as well as improving forecasting and the establishment of early warning systems, to encourage adaptation by farmers. The project will include disaster risk preparedness, seasonal forecasting and flood forecasting, capacity building in spatial planning, and disaster insurance for the poor.	Agriculture; disaster preparedness
Confronting climate change			
Ghana	Information support system for the sustainable management of the coastal zone of Ghana	Provision of information required in support of the coastal zone's rationale management, including more accurate data collection and map creation.	Coastal management

Country	Specific role in the adaptation action	Details on activities with relevance to ICT	Areas of focus
Rwanda	Six immediate national adaptation projects were prioritized, one of which has an ICT component	The project's objective is to enhance hydro-agro-meteorological early warning systems and rapid interventions, and to decrease the risk to vulnerable populations and sectors.	Early warning; disaster preparedness; capacity- building
Niger	The NAPA proposes use of ICTs in the following areas: a) to support resilience and adaptive behavior by providing agro-meteorological information to rural producers; b) integration of major climate sensitive disease information into the health sector	In rural areas the aim is to encourage farmers to use agro-meteorological information in their production work so as to reduce soil erosion and to adapt to climate variability. The Integrated Food-Security Information System function is to monitor food shortages and malnutrition. In the health sector ICTs will provide relevant information for integration of the various aspects of planning and operation management. They should also enable a permanent health watch system especially in the prevention and treatment of malaria and meningitis.	Agriculture; health; capacity-building
Togo	The NAPA stresses the importance of ICTs for agriculture by providing agro-meteorological information and early warning systems for floods	Where adaptation for agricultural production systems is concerned, three regions were identified through techniques focused on improved agro-meteorological information. Through these techniques farmers are encouraged to use meteorological information in farming activities with the aim of increasing food security. The development of an early warning system was identified for the use of real time information on floods in the Maritime and Savanna regions. This will reinforce the capacity of the national meteorological service and rural radio stations to establish meteorological forecasting, ensure an adequate response and reduce risks.	Agriculture; food security; early warning system

2.2 Adaptation programs and projects in Africa

A number of projects and programs are currently being implemented in Africa to support adaptation to climate change. Some of these initiatives are quite large, encompassing many African countries. Others are smaller, local initiatives. This section highlights examples of projects and programs which are underway that specifically target efforts to adapt to climate change.

2.2.1 Continent-wide programs and projects

A few large climate change adaptation programmes and projects are currently being implemented that aim to meet the needs of countries across the whole of Africa. Major continental programs focusing on climate change adaptation with a budget above 50 million USD include:

1. the Climate Change Adaptation Support Programme for Action-Research and Capacity Development in Africa;
2. the Africa Adaptation Programme; and
3. the Climate for Development in Africa (ClimDev-Africa) Programme and its component, the African Early Warning and Advisory Climate Services.

The Climate Change Adaptation Support Programme for Action-Research and Capacity Development in Africa (CCAA)[111] was launched in 2006 with the goal of improving the capacity of African countries to adapt to climate change in ways that benefit the most vulnerable people and communities. With a budget of CND 65 million (USD 63 million) from the International Development Research Centre (IDRC) and the UK Department for International Development (DFID) over a five year period, the specific objectives of the project have been to:

- strengthen the capacity of African scientists, organizations, decision-makers and others to contribute to climate change adaptation;
- support adaptation by rural and urban people, particularly the most vulnerable, through action research;
- generate a better shared understanding of scientific findings on climate variability and change; and
- inform policy processes with good-quality, science-based knowledge.

The Africa Adaptation Programme (AAP)[112] aims to help African countries incorporate climate change risks into national development planning processes. The two-year (2009-2011) program was designed to create an environment for more informed and capable adaptation decisions and practices in each country. It was launched in December 2008 by the United Nations Development Programme (UNDP) with a budget of USD 92 million provided by the Government of Japan. All 20 projects are being implemented by national governments with technical support from UNDP country offices. The AAP especially focuses on the following objectives:

[111] IDRC, http://www.idrc.ca/ccaa/ev-127593-201_104835-1-IDRC_ADM_INFO.html
[112] UNDP, http://www.undp-adaptation.org/africaprogramme/

- to strengthen long term planning and thereby enable countries to manage both existing and future risks associated with climate change;
- to build effective leadership and institutional frameworks for enhanced coordination and cohesion of programmes
- to support the piloting of adaptation initiatives in the field;
- to identify a range of financing options for sustained adaptation; and
- to build knowledge management systems and promote information sharing.

The Climate for Development in Africa Programme (ClimDev-Africa)[113] aims to improve and facilitate practices, services, observation networks and communication with stakeholders in order to enable effective climate change mitigation and adaptation in Africa. Recognizing the disconnection between climate science and its use in decision-making, the programme has been developed not only to improve climate information and services but also to strengthen the use of this information for policy and decision-makers at all levels.[114] It is intended for all African countries over a period of 10 years, with an estimated budget of around USD 200 million. The programme will seek to increase the level of activities for climate change adaptation, provide a coherent framework for the coordination of related adaptation activities in Africa,[115] and implement pilot adaptation projects.

One component of Clim-Dev is the African Early Warning and Advisory Climate Services (AEWACS/ViGIRisC)[116] project. This aims to reinforce the capacity of African countries to adapt to climate change and climate variability using early warning and advisory tools and services.[117] The project is led and coordinated by ACMAD, and has a total budget of Euro 4 million over a three year period (2009-2012).[118] The main project domains involved are food security, water resources and risks associated with river flow (Congo, Niger), coastal zone management, storm surges, severe and high impact weather phenomena, and the wider protection and health of citizens.

[113] AFDB, http://www.afdb.org/en/topics-sectors/initiatives-partnerships/climate-for-development-in-africa-climdev-africa-initiative/

[114] Since 2007, progress was made on developing the operational design of programme with the establishment of the African Climate Policy Centre (ACPC) and the Clim-Dev Africa Special Fund. ACPC is based at ECA and will play a central role in guiding and facilitating the overall implementation of the Programme. The CDSF hosted by the AfDB will provide a channel for demand-led funding on field-level operations. In October 2010, Clim-Dev was launched at the 7th African Development Forum.

[115] Boulahya (2010).

[116] Projet de Vigilance et Gestion Intégrée du Risque Climatique en Afrique (ViGIRisC)

[117] The programme has been presented as a component (or even precursor) of the ClimDev Africa. Both programmes aim to bridge the communication gap between the meteorological community and the political, scientific and technical communities in charge of sustainable development

[118] The funding comes from various contributions including the French Ministry of Foreign and European Affairs, French Global Environment Fund, African Bank of Development, UNECA, IFRC, ACMAD, and partners. (ACMAD no date)

Alongside these continent-wide programmes are a number of initiatives that address the needs of smaller groups of countries from the different regions of Africa. Examples of such projects and/or programmes which have a cross-sectoral focus include the following:

- Climate Change Adaptation and Development Initiative (CC-DARE).[119] This provides demand-driven technical and financial assistance to 15 sub-Saharan African countries[120] to improve their ability to remove barriers and create opportunities for integrating climate change adaptation into national development planning and decision-making frameworks.CC-DARE is a joint ongoing initiative of UNEP and UNDP.

- Adaptation Learning Programme (ALP).[121] The objective of this programme is to increase adaptive capacity in vulnerable communities in four countries (Ghana, Kenya, Mozambique and Niger) through the application of best practice models that influence policies and practice for community-based adaptation. It is funded by Care International and launched in 2010.

- Adaptation of Land Use to Climate Change in sub-Saharan Africa (ALUCCSA).[122] ALUCCSA aims to estimate the effects of different future climate scenarios on land use for the next fifty years at a regional/local scale for Sub-Saharan Africa working from Burkina Faso and Ethiopia as a basis for decision-making by farmers and political authorities. The research program ran from June 2008 to May 2011 and is led by the Centre for Tropical and Subtropical Agriculture and Forestry and Georg-August University of Göttingen, with funding from the German development agency GTZ.

- The Great Green Wall for the Sahara and Sahel Initiative (GGWSSI)[123] is a priority program of the AU/NEPAD action plan. It seeks to address desertification and climate change through a range of integrated interventions concerned with natural resource management. These cover multi-sectoral issues (land, water, forest, soil, livestock, and agriculture) in the Saharan and Sahel dryland ecosystems. The initiative is funded under the AU-EU partnership on climate change, endorsed by African Heads of States and Government in 2007 and currently ongoing (€1.75 million).

- The Climate Change and African Political Stability (CCAPS) program.[124] The aim of this program is to investigate the linkages between climate change and security issues in Africa through a series of case studies across Africa. The programme is funded by the United States Department of Defense (USD 7.6 million).[125]

[119] CCDARE, http://www.ccdare.org/

[120] There are presently 11 participating countries: Benin, Ethiopia, Ghana, Malawi, Mozambique, Rwanda, Senegal, Seychelles, Togo, Tanzania, Uganda

[121] CARE, http://www.careclimatechange.org/files/adaptation/ALP.pdf

[122] GIZ, http://www.gtz.de/de/dokumente/gtz2009-8-en-factsheet-aluccsa.pdf

[123] OSS, http://www.oss-online.org/pdf/imv-en.pdf ; ACP, http://www.scopeacp.net/sobi2/great-green-wall-for-sahara-and-sahel-initiative

[124] CCAPS, http://ccaps.strausscenter.org/about

[125] It is being implemented by the Strauss Center for International Security and Law of North Texas University in collaboration with Trinity College Dublin, the Institute for Security Studies, and College of William and Mary.

2.2.2 Sector-focused programs and projects

Alongside these multi-country, multi-sector projects are others that focus on specific sectors such as agriculture, water, energy and meteorology. The following paragraphs briefly describe some examples of these projects, and demonstrate the diversity of needs that are being addressed through current initiatives.

Agriculture

- "Strategies for Adapting to Climate Change in Rural Sub-Saharan Africa: Targeting the Most Vulnerable."[126] The objectives of this project are to reduce the vulnerability of rural households to climate change through better-coordinated and targeted food system adaptation strategies, and to provide regional organizations, policymakers and farmers in eleven sub-Saharan African countries[127] with tools to identify and implement appropriate adaptation strategies. This is primarily a capacity-building project which was implemented by the International Food Policy Research Institute with funding from GIZ and the World Bank during the period from May 2008 to April 2011.
- "Developing rice and sorghum crop adaptation strategies for climate change in vulnerable environments in Africa" (RISOCAS).[128] This project aims to deliver coping strategies for crop adaptation to changing climatic conditions, along with tools and methodologies enabling stakeholders to develop these strategies further and/or to apply them to other crops or environments. The overall goal of the project is to develop an operational methodology to measure the impact of climate change scenarios on crop responses for cereal-based farming systems of Africa, using case studies from Senegal, Mali and Madagascar. It is being implemented by the Institute for Crop Production and Agro-ecology in the Tropics and Subtropics at the University of Hohenheim.

Water and energy

- "The Water, Climate and Development Programme in Africa."[129] The goal of this program is to address water as a critical part of sustainable regional and national development, and thereby contribute to climate change adaptation for economic growth and human security. The program is being implemented at trans-boundary, national and local levels in eight countries and four river basins in Africa during the period from January 2011 to December 2015. Program

[126] FANPRAN, http://www.fanrpan.org/themes/eachproject/?project=2
[127] Burkina Faso, Burundi, DRC, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania, Uganda
[128] RISOCAS, https://risocas.uni-hohenheim.de/
[129] ENTWICKLUNG, http://www.entwicklung.at/fileadmin/media/Aktuelles/Global_Water_Partnership_Afrika/WCDP_flyer_final_logo.pdf

implementation is led by governments in collaboration with Regional Economic Communities, river basin organizations and AMCOW, and is facilitated by the Global Water Partnership (GWP) along with other partners. It is initially expected to cost 10.8 million euros.[130]

- "Climate Proofing Energy Systems: Vulnerability-Adaptation-Resilience."[131] This research project of HELIO International has now been completed. It sought to develop a methodology and indicators to evaluate the vulnerability of energy systems to climate change. This can be used to help policy-makers to identify and understand issues that need to be addressed in order to ensure energy security and access in a changing climate context. The project began in 2007 and covered ten sub-Saharan African countries.[132]

Forestry

- "Adapting the Framework of Forestry Policy to meet the needs of climate change in the MENA region."[133] This project aims to improve sustainable management of forest ecosystems and the maintenance of environmental services in the Middle East and North Africa region. It focuses on policy formation, capacity-building, knowledge-sharing and awareness-raising work in Algeria, Morocco, Lebanon, Tunisia, Syria and Turkey, and will be underway between 2010 and 2014. It is funded by the German Federal Ministry for Economic Cooperation and Development and implemented by the Collaborate Partnership on Mediterranean Forests.

Health

- "Transferring the Malaria Epidemic Prediction Model to Users in West Africa."[134] This project, which was funded by the Climate Change Adaptation in Africa (CCAA), took place between 2007 and 2010 in Kenya, Tanzania and Uganda. It aimed to increase medical capacity to address malaria epidemics. This project addressed: (1) the local terrain and immune profile of affected individuals; (2) awareness-raising among policy makers and health officials concerning the modeling and prediction of malaria epidemics; and (3) the role of non-biophysical factors in epidemics and their control.

Meteorology

- "The Regional Science Service Centre for Adaptation Climate Change and Sustainable Land Management in Southern Africa."[135] This program, which is funded by the German Federal

[130] GWO, http://www.gwp.org/en/Press-Room/Press-Releases/GWP-and-AMCOW-Unveil-Water-Climate-and-Development-Programme-for-Africa/
[131] HELIO International, http://www.helio-international.org/uploads/Global%20Report.En.pdf
[132] Benin, Burkina Faso, Cameroon, DRC, Kenya, Mali, Nigeria, Senegal, Tanzania, Uganda
[133] GTZ, http://www.gtz.de/en/weltweit/maghreb-naher-osten/tunesien/32875.htm
[134] Adaptation Learning Mechanism, http://www.adaptationlearning.net/transferring-malaria-epidemic-prediction-model-users-east-africa
[135] RSSC, http://www.sasscal.org/

Ministry of Education and Research, is being undertaken in Angola, Botswana, Namibia, South Africa and Zambia. It focuses on sustainable land management and provides an arena for knowledge sharing about land use resource management in its region.

Most of these programs and projects focus on capacity-building (including policy linkages) and research activities.

2.2.3 National programs and projects

As well as multi-country programs and projects, there are many projects underway in climate change adaptation which focuses on an individual country in Africa. As with participation in regional and continental projects, these tend to be concentrated in specific regions and countries. In North Africa, for example, relatively few (about five) large adaptation projects are underway in other countries, but over a dozen are being implemented in Morocco.[136] In West Africa, the largest numbers of adaptation projects are taking place in Ghana, Mali, Niger and Senegal.[137] In East Africa, the most active countries are Ethiopia, Kenya, Rwanda and Uganda. Malawi, Mozambique and South Africa have the greatest number of adaptation projects underway in Southern Africa. These differences reflect variations in the degree to which national governments perceive climate to be a priority area of concern, the level of engagement in the issue by local research institutes and non-governmental organizations, and the extent to which adaptation-focused programming is a priority for international development assistance organizations investing in a country.

The focus of projects which address the needs of individual countries also varies from one region to another. The greatest emphasis of projects across Africa is on agriculture, water and risk reduction. In North Africa, the sectors in which adaption projects are concentrated concern water resources, agriculture and coastal zones.[138] In West Africa, the majority of national projects focus on water and agriculture. Other sectors identified as priorities—livestock/pastoralism, health, coastal zones and meteorology—lack national projects.[139] In Southern Africa, projects revolve around agriculture, water, policy formulation and integration, and risk reduction.[140] Most countries in East Africa are primarily agricultural economies, and so their project experience also focuses on agriculture and water resources, particularly in Kenya and Tanzania. Disaster risk reduction has been important in Ethiopia, Djibouti, and Rwanda.[141] Central Africa has the lowest number of adaptation projects and programs in Africa. The

[136] IISD, *Review of Current and Planned Adaptation Action: North Africa*, first draft (April 2011), unpublished report.
[137] IISD, *Adaptation Review of Current and Planned Adaptation Action: West Africa*, first draft (April 2011), unpublished report.
[138] IISD, *Adaptation Review: North Africa*
[139] IISD, *Adaptation Review: West Africa*
[140] IISD, *Adaptation Review: Southern Africa*
[141] IISD, *Adaptation Review: East Africa*

limited adaptation action found in this region focuses on agriculture and food security, risk reduction and coastal zone management.[142]

Whether a project involves one or more countries, most adaptation initiatives in Africa are concerned with capacity building, policy formation and research rather than focusing directly on physical transformation on the ground. However, African states are working toward implementing adaptation actions that are based around physical interventions, in recognition of their commitment to addressing current climate variability and minimizing vulnerability to longer-term climate change.

2.2.5 ICTs in current programs and projects

As described above, many African countries are participating adaptation projects of various kinds. Some of these have components that include ICTs. Examples of these projects are set out in Table 2-3. These projects are predominantly concerned with mapping, monitoring and forecasting to improve the integration of information based on climate projections into early warning systems and disaster preparedness, agriculture and water management. The examples which are listed in this table have the following goals:

- generating, organizing and communicating information about the risks resulting from climate change, climate variability and extreme climate events, as well as preparing for their effects on food security and water supply;[143]
- developing an information system within the food sector that is better able to reflect household access to food and food consumption;
- developing early warning and hazard risk information systems to deal with the additional fire hazards associated with climate change and to enable integrated fire management; and
- developing ICT mapping tools to map vulnerable areas and provide spatial representations of climate change impacts.

[142] IISD, *Review of Current and Planned Adaptation Action: Middle Africa*, first draft (April 2011), unpublished report.
[143] IDRC, www.idrc.org/ccaa

Table 2-3: Overview of regional projects with an ICT component in Africa

Project Title	Objective	Sector focus	Countries Involved
Addressing drivers of vulnerability and Building response capacity			
Advancing Capacity to Support Climate Change Adaptation: Five Pilot Projects	This program aims to reduce the vulnerability to climate change of poor populations in sub-Saharan Africa by mobilizing scientists to inform political decision-making. It seeks to do so by means of five pilot projects in rural and urban populations. The program emphasizes the generation, organization and communication of information on the risks resulting from climate change, climate variability and extreme climate events, as well as preparation for their effects on food security (Cameroon, Ethiopia, Kenya) and water supply (South Africa, Burkina Faso).[144] *Implementing agency*: UNEP *Funders*: IDRC and DFID	Mapping; water; agriculture	Burkina Faso, Cameroon, Ethiopia, Kenya, South Africa
Capacity-building and technical assistance for adaptation and use of household food and nutrition security monitoring tools	The dimensions of household access to food and food consumption are insufficiently taken into consideration in information systems. The Nutrition Division of FAO is providing training and technical assistance for the adaptation, use, analysis and interpretation of simple household food and nutrition security monitoring tools. *Implementing agency*: FAO *Funders*: EC	Agriculture (food)	Ethiopia, Kenya, Malawi, Mozambique, Somalia, West Bank and Gaza,
Reducing and managing risks, and confronting climate change			
Reducing Disaster from Wildfire Hazards Associated with Climate Change, 2011-2014	To develop and implement integrated disaster risk management strategies to address fire hazards and risks that is induced by climate change. Expected outputs: • Development of an early warning and hazard risk information system to deal with the additional fire hazard risks associated with climate change • A paradigm shift from reactive firefighting to an integrated fire management system which can cope with fire hazards that are induced by climate change, and is based on capacity built at local level • Introduction to good practices in adaptive management of fire risks disseminated at national and regional levels. *Implementing agency*: UNDP *Funder*: GEF Special Climate Change Fund	Early warning; risk management; Fire	South Africa (Western Cape, Eastern Cape, and Freetown province)
South Africa Risk and Vulnerability Atlas: electronic spatial database[145] (2010)	This electronic database provides information on critical areas, sectors, *etc*. that are vulnerable to climate change. The South African Risk and Vulnerability Atlas directly support access to and visualization of data dealing with the impacts of global environmental change on human and natural environments. This project is funded by the Department of Science and Technology. *Implementing agency:* Ministry of Science and Technology	Mapping	For South Africa with minimal spatial data and information available for: Swaziland, Mozambique Botswana, Namibia

[144] IDRC, www.idrc.org/ccaa
[145] RAVA, http://rava.qsens.net/

2.2.4 Capacity-building initiatives and public education programs in Africa

In 2001, the UNFCCC Conference of Parties set out a climate change capacity-building framework which specified requirements for the development and transfer of technologies, capacity-building in developing countries, and economies in transition.[146] Ten years later, a new UNFCCC report assessed the implementation of that decision by reviewing National Communications, NAPAs, national capacity self-assessments, technology needs assessments and annual submissions from governments and relevant organizations.[147] This report presented its conclusions in four main areas:

a) capacity building activities by governments,
b) needs and gaps in the implementation of the framework,
c) capacity building activities in UN agencies, and
d) capacity building activities under the Kyoto Protocol.

The report listed the following areas in which capacity-building activities (for both mitigation and adaptation) have been conducted by governments:

- Establishment and strengthening of national coordination entities to support the implementation of climate change activities.
- Development of regulatory frameworks to facilitate the implementation of activities that address climate change and to promote their alignment with existing development targets such as the Millennium Development Goals.
- Training activities to prepare GHG inventories according to the standards and methods set by the Intergovernmental Panel on Climate Change (IPCC), and to maintain inventory management systems.
- Activities to support the design and implementation of National Adaptation Plans, strategies, programmes and projects, including research and training activities intended to increase understanding of climate change impacts, risks and vulnerabilities.
- Capacity-building to carry out plans to mainstream renewable energy, energy efficiency and clean technology investments through research and implementation of local demonstration projects.
- Training activities to improve capacity for activities concerned with reducing emissions from deforestation and forest degradation (REDD) in developing countries, including the preparation of REDD strategies and/or complementing existing strategies and policy frameworks for forest and environmental management.

[146] Decision 2/CP.7 - http://unfccc.int/resource/docs/cop7/13a01.pdf#page=5
[147] http://unfccc.int/cooperation_and_support/capacity_building/items/1033.php

- Training activities to enhance the capacity of national meteorological services to carry out research and systematic observation of the climate system.
- Capacity-building to support the development of technology action plans and to identify appropriate policy actions to enable technology transfer.
- Development of training materials such as guidelines, manuals and information bulletins devoted to climate change issues for specialists and decision makers involved in the design and implementation of climate change activities.
- Capacity-building to identify, develop and undertake clean development mechanism (CDM) project activities, including training and workshops for relevant stakeholders such as local governments, civil society and the private sector; to translate CDM materials into local languages; and to provide technical support for the establishment and maintenance of Designated National Authorities (DNAs).
- Capacity-building to assist governments in mainstreaming climate change within development planning and to promote programmatic coherence when governments carry out adaptation strategies and plans of action.
- Implementation of national strategies and programmes on education, training and public awareness in collaboration with civil society organizations, including the mainstreaming of climate change at all educational levels and increasing awareness of the causes and effects of climate change among the public at large.
- Creation of climate change portals and databases for the dissemination of information to national and local government institutions as well as to relevant stakeholders and the wider public.
- Implementation of South-South cooperation activities, including training on the drafting of National Communications and technical support to establish Designated National Authorities.

Governments that responded to the UNFCCC survey for its report identified a number of needs and gaps in the process for implementing the agreed capacity-building framework. These included the following needs:

- to develop new legislation addressing climate change and/or to integrate it with existing national legal frameworks;
- to build and/or develop permanent national institutional structures to work on climate change issues;
- to support initiatives that address climate-related risks and extreme events associated with climate change;
- to train staff on climate change issues and retain trained staff;
- to support energy management and energy audit, and improve access to energy efficiency technology databases;

- to increase technical and financial support for research and systematic observation;
- to provide technical support for the development of technologies which can address adaptation needs;
- to generate country-specific and disaggregated climate data, especially for Least Developed Countries and Small Island Developing States;
- to establish permanent entities responsible for preparing GHG inventories and carrying out the application of models recommended by the IPCC to assess the potential for reductions in GHG emissions;
- to provide technical support for the development of reliable models for assessing vulnerability;
- to increase national capacity to implement CDM project activities;
- to increase support for awareness-raising activities, especially relating to the CDM, for policymakers, technical staff and the public at large; and
- to increase regional cooperation on the issues of education, training and public awareness.

The UNFCCC report identifies a number of capacity-building initiatives by UN organizations. These are coordinated through the High Level Committee on Programming Working on Climate Change of the Chef Executives Board for Coordination of the United Nations.[148] Several meetings, workshops, roundtables, and programs of activities have been held to widen stakeholder participation within capacity-building activities under the Kyoto Protocol. One notable initiative which focuses on sub-Saharan Africa is the Nairobi Framework,[149] which seeks to improve participation and to expand the level of CDM activities by organizing fora and regular exchanges of information. Another is the establishment of a global virtual information exchange called the CDM Bazaar which has been designed to encourage information exchange and dialogue among current and potential future project participants and market players. A few African organizations are listed in its profiles.[150]

Several capacity building initiatives have therefore been undertaken within the framework of the UNFCCC with some degree of success. These implementations have also revealed some gaps and needs particularly in the area of adaptation.

African delegates to UNFCCC conferences identified a need to build capacity on climate change issues, targeted at negotiators and tailored to the FCCC process, as early as the Fourth Conference of Parties in 1998.[151] A Climate Change Capacity Project was developed to address this need.[152] Workshops were held

[148] http://unfccc.int/cooperation_and_support/capacity_building/items/1033.php
[149] The Nairobi Framework is jointly implemented by the United Nations Development Programme, the United Nations Environment Programme (UNEP), the World Bank Group, the African Development Bank, the United Nations Conference on Trade and Development, the United Nations Economic Commission for Africa, the United Nations Institute for Training and Research and the secretariat. It recently organized the Third Africa Carbon Forum.
http://www.usaid.gov/our_work/environment/climate/policies_prog/capacity.html
[150] http://www.cdmbazaar.net/
[151] http://www.iisd.org/climate/cccp_africa_bg.htm

in Senegal for African delegates, and in the Latin American and the Caribbean region. A survival guide for developing country climate negotiators was also prepared.[153] Several development agencies and international financial institutions have remained committed to implementing capacity-building initiatives in developing countries. Some examples include:

- UNEP, UNDP and UNITAR have participated in several joint initiatives aimed at developing the capacity of LDCs to participate effectively in UNFCCC conferences; and in assessing existing climate change training courses/modules with the aim of identifying further needs in this area.[154]
- The International Institute for Environment and Development (IIED) has undertaken workshops on 'What REDD+ Can Learn from Participatory Forest Management' and 'Lessons Learned from REDD Pilot Projects in Tanzania'.[155]
- A European Capacity Building Workshop for West Africa has been held, focusing on the discussion of strategies for effective decision-making on climate change at the international level, and the translation and implementation of those decisions to national and field levels.[156]
- UNEP has published a document entitled *Ready, Willing and Able: Empowering Countries to Meet the Climate Challenge*, which focuses on climate change capacity-building success stories.[157]
- The United Nations Economic Commission for Africa (UNECA) has organized the Seventh African Development Forum (in collaboration with the African Development Bank and the African Union). This focused on the use of science, technology, innovation and capacity-building to address climate change by recognizing the gaps in scientific knowledge for decision making by policy makers; on the potential for technology to address climate change, including challenges in intellectual property rights (IPR); on the role of innovative technologies; and on the tools required to address capacity gaps which must be overcome in order to empower researchers, industry, communities and individuals.[158]
- START International and the Open Society Institute held a forum on "Education, Capacity Building, and Climate Change: A Strategy for Collective Action in Africa" in 2010. This explored the role of African universities in promoting education on climate change adaptation through research, curriculum development and teacher training. It also considered ways of engaging civil society more fully in education concerned with adaptation outside the university context.[159] The forum brought together participants from the whole African continent.

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[152] http://www.iisd.org/climate/cccp_africa_bg.htm
[153] http://www.iisd.org/cckn/delegation.htm
[154] http://www.iisd.ca/mea-l/guestarticle66a.html
[155] http://www.iied.org/climate-change/key-issues/climate-negotiations-capacity-building/cop17-workshop-making-redd-deliver-
[156] http://www.iied.org/climate-change/key-issues/climate-negotiations-capacity-building/2011-ecbi-regional-workshop-for-wes
[157] http://climate-l.iisd.org/news/unep-launches-climate-change-capacity-building-success-stories/
[158] http://www.uneca.org/adfvii/documents/IssuePaper10Science-technology-innovation-and-capacity-building.pdf
[159] http://start.org/forum2010/about

- Private sector-capacity building initiatives have been implemented at national level in a number of countries, aimed at addressing the knowledge gaps evident within public, private and civil society structures. One example is the Regional Capacity Building Partner's (RECABIP) workshop on "Strengthening the Response to Climate Change in Development Programming'.[160] Another is the Imbewu and Econ Pöyry workshop in South Africa for public and private institutions, which focused on the international climate change regime, on exploring recent South African policy developments, and on accelerating the uptake of CDM project activities.[161]
- There have also been capacity-building initiatives concerned with media awareness. UNESCO has developed a capacity-building guide for young journalists.[162] A climate change media partnership network initiated was set up by Panos, Internews and IIED in 2007 to offer fellowships to journalists from developing countries.[163] The African Conference of Journalists focused its 2011 annual gathering of over 600 journalists from the African continent on climate change capacity building.[164] There are also several networks that share climate change knowledge between partner media institutions, including the Network of Climate Communicators of the Greater Horn of Africa and the Media for Environment, Agriculture and Development in Namibia, formed within the Earth Journalism Network.[165]
- Several organizations have included capacity-building on climate change issues within their upcoming programmes. The Rockefeller Foundation, for example, is seeking to address knowledge gaps in African agricultural sector research by testing interventions, developing the scientific evidence base and building the capacity of agricultural scientists and experts.[166] USAID sees human and institutional capacity-building in the areas of adaptation, clean energy and sustainable landscapes as an important part of its approach. It does this through education, training and outreach.[167]

These initiatives have contributed to building capacity in the private, public, non-governmental/civil society, media, academic and policymaking communities. However, it is important not to overestimate their significance. Many of the workshops and other activities that take place are on a small scale and poorly integrated with one another. No assessment has been made of the extent to which they are successful in transferring knowledge or of the extent to which that knowledge is then passed on within wider target populations or translated into policy and practitioner decision-making or implementation on the ground. In addition, there remain substantial capacity-building gaps particularly in research, evidenced by the low numbers of documented and researched ICT-related climate change stories; in

[160] http://www.recabip.com/courses_climate_change.htm
[161] http://www.engineeringnews.co.za/article/climate-change-capacity-building-2009-04-24
[162] http://www.unesco-ci.org/projects/eng/IPDC-Projects-database/List-of-all-projects/ipdc1024
[163] http://cdkn.org/2011/08/building-journalists-capacity-to-create-change-a-cdkn-impact-story/
[164] http://www.highwayafrica.com/?page_id=5
[165] http://earthjournalism.net/content/capacity-building-focus-global-south
[166] http://www.rockefellerfoundation.org/what-we-do/current-work/developing-climate-change-resilience/african-agriculture-climate-change/
[167] http://www.usaid.gov/our_work/environment/climate/policies_prog/capacity.html

policy, to narrow the gaps between practitioners, researchers and policy makers (see the Senegal Case study in Chapter 4); and in the public sector management of water, food security, and energy use. [168]

2.3 Conclusions

African countries have identified a number of sectors in which critical interventions are required to increase their capacity to adapt to the impacts of climate change. The most important of these are agriculture, water, health, forestry and coastal zone management. Governments are working collaboratively through intergovernmental bodies to further their adaptation efforts, and are preparing national adaptation strategies and plans. Numerous adaptation-focused projects are being implemented in one or more countries by a variety of research institutes; government bodies, international organizations and non-governmental organizations, and capacity building initiatives have been targeted at various levels of society.

Within all of this activity, however, the level of ICT involvement appears limited in scope and impact. ICTs are generally perceived to be useful, and are being used, in the following areas:

- creating climate change projections and making databases of climate data available for sectoral, national and regional applications;
- developing and revising early warning systems;
- creating monitoring systems for water quality, health and diseases; and
- developing capacity-building and awareness-raising applications including the sharing of climate data, projection and adaptation actions.

There are opportunities for more extensive and substantive use of ICTs in support of adaptation to climate change. Chapter 3 provides examples of current practice in ICT use for adaptation, and explores the challenges and opportunities associated with expanding their application.

[168] http://www.devex.com/en/articles/the-future-of-capacity-building-in-africa-a-conversation-with-frannie-l-autier

Chapter 3 - ICTs and Adaptation: Challenges and Opportunities

Chapter 1 described and categorized, along a continuum of activity, a range of ICT tools that can be used to support adaptation to climate change. These tools can support efforts that:

- address the underlying drivers of vulnerability to climate change, principally through traditional development efforts;
- lay the foundations for adaptation action by building response capacity, for example by strengthening institutions, building capacity to use tools, and sharing technologies;
- help manage climate risks—whether due to natural climate variability or climate change—by facilitating the integration of climate considerations into decision-making; and
- support the monitoring and management of climate risks directly attributable to anthropogenic climate change.

Along this continuum, the focus of adaptation action moves from actions which respond to broad development and other challenges of which climate change now forms a part, to actions that are driven by consideration of specific climate risks brought about either by current climate variability or by longer term climate change themselves.

The framework for examining the intersections between ICTs and adaptation to climate change which was presented in section 4 of Chapter 1 also distinguished between two main types of ICT tools and applications—large-scale implementations and small-scale implementations.

- Large-scale implementations include tools such as:
    - early warning systems
    - weather management,
    - remote sensing and meteorological systems,
    - smart , and sensor networks, and
    - GIS, Global Positioning Systems and modelling.

- Small-scale implementations include tools that support knowledge management, information sharing and planning and decisions making, and low-tech applications, such as mobile phones, which are used by individuals and/or are readily available within communities.

The framework in Chapter 1 also identified a number of policy considerations concerning how these tools can be used to address the drivers of vulnerability to climate change, build response capacity and enhance decision-making.

Three strategic policy considerations are important in the context of large-scale ICT implementations:

- support for capacity-building, training and education;
- the potential for infrastructure deployment to generate opportunities for local business and the need for governments to address infrastructure deficits; and
- policies to support open data approaches, which make information more available for decision-making and research.

The most important policy considerations concerning small-scale implementations are:

- support for the development and deployment of communications strategies;
- public information dissemination and awareness-raising;
- the encouragement of public-private partnerships; and
- policies that will improve access and affordability for handheld and mobile devices which can be used to disseminate information to end-users and exchange information with them.

This chapter explores:

- the potential role of ICTs in reducing vulnerability and building response capacity;
- their potential role in reducing risks directly associated with climate variability and climate change;
- the challenges associated with applying ICTs in climate change adaptation, including the relationship between public and private sectors, technical and infrastructural concerns, capacity gaps, indicators and monitoring; and
- opportunities for the expanded use of ICTs in facilitating adaptation, highlighting the growing commitment of national governments to address adaptation concerns, and the recent growth of telecommunications capacity in Africa.

3.1 The role of ICTs in reducing vulnerability and building response capacity

It is important to recognise that adaptation to climate change does not consist solely of interventions by governments, donors and other institutional actors. People in their daily lives make decisions and choices which reflect their own adaptation to the changing circumstances around them. Likewise, the use of ICTs in climate change adaptation is not solely a matter of programmes, projects and other interventions which are initiated outside the communities that are affected. ICT resources are increasingly widely available to people throughout Africa. Every day, individuals and communities, as well as government agencies and other organisations, are making use of ICTs in ways that help them to reduce their vulnerability to the impacts of climate change.

Most often, completion of these tasks is not driven by concerns related to the management of current or future climate risk. Rather, they are driven by pressing needs. In the case of individuals, these needs are concerned with the priorities of everyday life – growing or buying food, finding employment, remaining healthy, paying for children's education, *etc.* In the case of governments, they are determined by the priorities of development—the desire to strengthen health care systems, improve governance, build infrastructure, track the spread of diseases, provide market information, enhance communication systems, survey groundwater sources, diversify economic systems, and achieve many other development related goals, only some of which are perceived as being directly related to environmental issues such as climate change. ICTs play a significant part in efforts to achieve all of these goals today, and are expected to play a greater role in future. In doing so, they are helping to reduce exposure and increase adaptive capacity—and therefore serendipitously helping to reduce vulnerability to climate change in both near and longer terms. Examples of how small- and large-scale ICTs are contributing to development and, by extension, helping to reduce vulnerability and build response capacity to climate change are presented in the following sections of this chapter, beginning with profiles of small-scale applications.

3.1.1 Small-Scale Applications

Within the ICTs and adaptation framework presented in Chapter 1, small-scale applications of ICTs that can contribute to climate change adaptation may be broadly divided into two groups:

(1) low-tech ICTs such as mobile phones and General Packet Radio Systems; and
(2) knowledge communication tools such as information-sharing systems, planning tools and decision support tools.

Low-tech ICT Tools

Many examples could be provided of the use of mobile/smart phones in building the resilience of individuals and communities in different development sectors, for example by disseminating information about market prices or the allocation of storage facilities so that farmers can access more resources when food is less available or disease occurs. Two widely reported examples of such applications from East Africa are M-PESA and Text-to-Change:

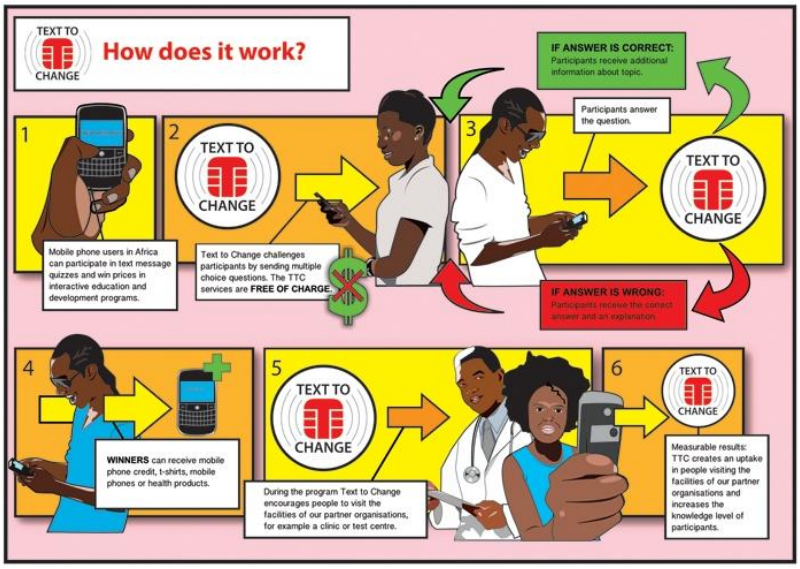
- **M-PESA**[169] is a mobile money transfer service that has had a powerful transformative effect on the way in which transactions are made and financial resources transferred in Kenya and, subsequently, more widely in East Africa. It is, it should be noted, a commercial business, not a development programme *per se*. Because it enables micro-transactions to be made much more

[169] Safaricom (2010). Mpesa. Retrieved December 2011 from: http://www.safaricom.co.ke/index.php?id=745

quickly, efficiently and cheaply than was previously possible, M-PESA has made it easier for money to be transferred from (for example) migrant workers and family members in urban areas to people in rural communities for investment in the development of livelihood activities, the education of their children and other ways. Although more research is needed into the impact of this change in money transfers, these "mobile money" transactions are believed to contribute directly and indirectly to the generation of savings that can be used in times of crisis, including those caused by changing climatic conditions.

- **"Text to Change"** is an application that brings together health education, data collection and location services to subscribers through the use of mobile phones. Supported by African mobile providers, the Dutch Ministry of Foreign Affairs, FC Barcelona and other partners, "Text to Change" uses SMS to challenge mobile phone users on their knowledge of health issues, refer them to HIV testing sites and gather age and gender data from participants which can be analyzed alongside their location (see FigureFigure 3-1). Participants in free multiple choice quizzes can win mobile phone minutes and soccer shirts as an incentive for participating.[170] By helping people to reduce their risk of HIV/AIDS (which has direct impacts on human health and indirect consequences for economic development), this ICT application is making a contribution to building a healthier population that is better able to withstand progressive and sudden climate impacts. A similar game-based process could be used to increase awareness of climate change, its potential impacts, and adaptation options.

Figure 3-1: Text to Change[171]



Source: http://texttochange.org/about-ttc

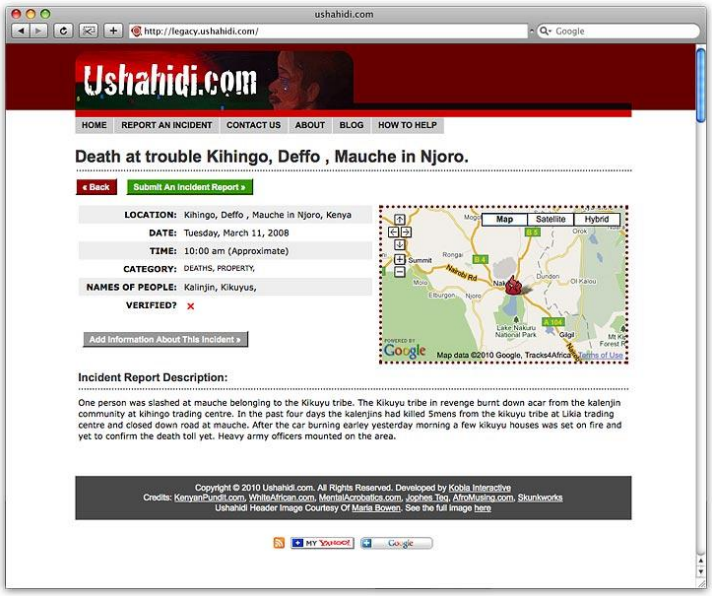
[170] Text to Change website: http://mobileactive.org/mobile-tools/text-to-change-sms-quiz
[171] Text to Change website: Retrieved December 2011 from: http://texttochange.org/about-ttc

Knowledge Communication Tools

- **Ushahidi** is a free, open source mapping and content management system which was developed after the 2008/09 post-election violence in Kenya (see Figure 3-2). It uses SMS, email and the internet to enable information generated by citizens, the media and non-governmental organizations to be combined with geographical mapping tools, thereby facilitating (for example) the distribution of early warnings and visualization of data to support response and recovery. Ushahidi can and has been used in many different ways since its emergence in Kenya. The platform has been used in Afghanistan, India, Lebanon, Mexico, the Philippines and Zambia for purposes such as monitoring elections and tracking unrest.[172] By helping to strengthen citizen engagement in the political process, Ushahidi contributes to improved governance capacity. In addition, its early warning and data visualization capabilities can be used to support response and recovery to climate-related disasters.

  Crouwdsourcing applications such as Ushahidi and those that can leverage mobile networks can be used to generate local, low-level, real-time data, such as landslides, floods and droughts that are usually hard to predict. In this way, they act as a means of verification and authentication of climate projections provided by larger systems such as weather stations.

Figure 3-2: Ushahidi showing the original web mashup[173]



Source: http://ushahidi.com/-/images/_screenshots/legacy.ushahidi.com_2.jpg

[172] Ushahidi, http://www.ushahidi.com
[173] Ushahidi, http://ushahidi.com/-/images/_screenshots/legacy.ushahidi.com_2.jpg

- **Development of a groundwater information system.** – In drought-prone areas, an accurate database of groundwater tables and replenishment rates is needed to help ensure that withdrawal of water takes place at rates that are sustainable. To address this need, efforts are underway in Laos to install software and hardware for groundwater mapping and database development, map groundwater supplies in drought-prone areas, enhance human resource capacity and develop a groundwater table information system.[174] Similar applications in Africa, where water scarcity is a concern in many places, could help provide the information and capacity needed to strengthen water management systems. They could also encourage more efficient use of water. Both of these are measures needed to reduce the risk of water emergencies arising today and in the future due to climate change.

- **Knowledge innovation and learning tools** - The growth of social media is having a marked influence on social structures, changing the ways in which many people relate to one another, and posing new challenges and opportunities for governance and administration. Social media enable people to create, use and redistribute tools and information in socially useful ways that were previously not possible.[175] A number of innovative and practical initiatives have emerged that leverage these media for the development of tools, applications, and technology for social gain benefit, while focusing on real-life problems.[176]

  One model of this is the MobileActive platform where applications, information, news and knowledge specific to social, environmental and governance issues are shared. It targets NGO communities worldwide through the development of mobile phone resources that can be used in sectors such as education, health, environment, disaster and human relief. A series of mobile tools, case studies, and research outcomes has emerged locally to address real problems both globally and in Africa.

  Random Hacks of Kindness (RHOK)[177] is another example of this kind of activity. It is based on a partnership model initiated between Google, Microsoft, Yahoo!, NASA, HP and the World Bank, in which subject matter experts with problems work with volunteers to address problems in their areas of concern. RHOKs are organized around city or national events called "hackathons" which bring together partners and volunteers to address a local issue. The 2010 RHOK took place in 21 cities around the world including Nairobi, Kenya, and Lusaka, Zambia. Volunteers and experts gathered at the Lagos Water Hackathon to develop a Water Purification Mobile Application which will enable the use of photographs of water samples taken by mobile phone

[174] UNFCCC profile of groundwater management in Lao PDR, http://unfccc.int/resource/docs/napa/laos01.pdf
[175] http://www.gnu.org/philosophy/
[176] http://www.rhok.org/about
[177] http://www.rhok.org

to test for impurities, portability and suitability for purposes other than drinking.[178] In Uganda, developers are exploring the use of SMS applications to pay water bills in ways that enhance transparency.[179] The Kenyan Water Hackathon is examining four problems relating to transparency and accountability that emerge from consumer complaints about water management and meter-reading. Future events are scheduled for 2012 in Kenya, The Gambia and South Africa. Hackathons illustrate an emerging model which may help communities to address local problems.

The growth of knowledge-sharing initiatives such as these will depend on the role that local private sector institutions play in such partnership models, and on how volunteers are incentivized for their contribution to delivering social outcomes. There is a risk that agendas and approaches could be led by Northern technical experts with little understanding of African conditions. Incentives for African subject matter experts will be required and further research is needed into how tools and applications such as these can contribute to problem-solving.

3.1.2 Large-scale applications

A number of larger-scale ICT applications are also contributing to efforts to reduce vulnerability and build response capacity. These tools include: GIS, modelling, planning and decision tools; smart systems and sensor networks; and early warning, weather management and meteorological systems. The following paragraphs provide illustrative examples of some of these applications.

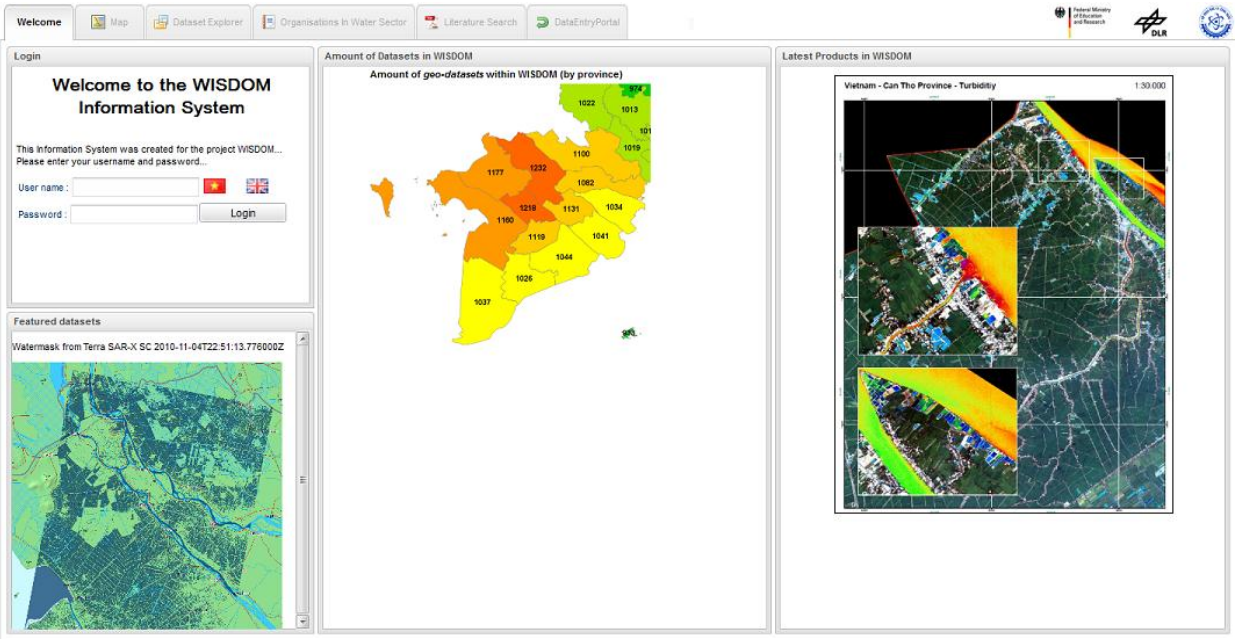
GIS, Global Positioning Systems and modeling

- **Water-Related Information System for the Sustainable Development of the Mekong Delta in Viet Nam** (WISDOM). This joint initiative of the governments of Vietnam and Germany seeks to develop and implement a platform for the collection, exchange and processing of water-related information. The information system allows the input of data of any kind (remote sensing data, GIS data, digital maps, *in situ* data, interpolated point measurements, *etc*.) and the organization and maintenance of these data to enable queries that address specific problems. The system consists of a data entry portal, a database in which the data are stored and organized, a visualization tool to display these data, and a query mask which enables sophisticated data analysis (see Figure 3-3). It can be used to analyze water quality, pollution and sediment load, to generate surface and sub-surface discharge models, and to monitor and evaluate the risk of floods and droughts.[180] Through WISDOM, the government of Vietnam is indirectly helping to reduce the country's vulnerability to climate change by improving management and planned use of its water resources. The data that are collected and analyzed can also be used to monitor the

[178] http://www.rhok.org/problems/water-purification-mobile-application
[179] http://www.rhok.org/problems/stop-job-losses-catch-thieves-ebilling-efiling-small-town-water-application-both-ngo-and
[180] WISDOM, http://www.wisdom.caf.dlr.de/

risk of floods and droughts and to assess changes in their patterns that might be due to climate change.

Figure 3-3: Front End Interface to WISDOM[181]



Source: http://indus.caf.dlr.de/Elvis/

Smart systems and sensor networks

- **Hartbeespoort Dam Integrated Biological Remediation Program.** This program, which is implemented by the South African Department of Water Affairs, aims to improve the biological health of the Hartbeespoort Dam in North West Province. One part of its work involves regulation of water use in the dam's catchment area. In support of this objective, a monitoring station has been installed along the Crocodile River, the main source of water held by the dam. The station contains a small monitor which is connected to the GSM mobile network for the transmission of data on an hourly basis to servers installed within and outside South Africa. The data concerned are generated by water probes which measure pH levels, temperature and water quality—the last of which tests the efficiency of upstream sewage treatment plants. Equipped with tablet PCs, dam managers are able to download data from the servers and take any necessary decisions immediately.[182]

[181] WISDOM, http://indus.caf.dlr.de/Elvis/

[182] Hartbeespoort Dam Integrated Biological Remediation Programme: http://www.harties.org.za/ and field visit conducted by IISD in July 2011.

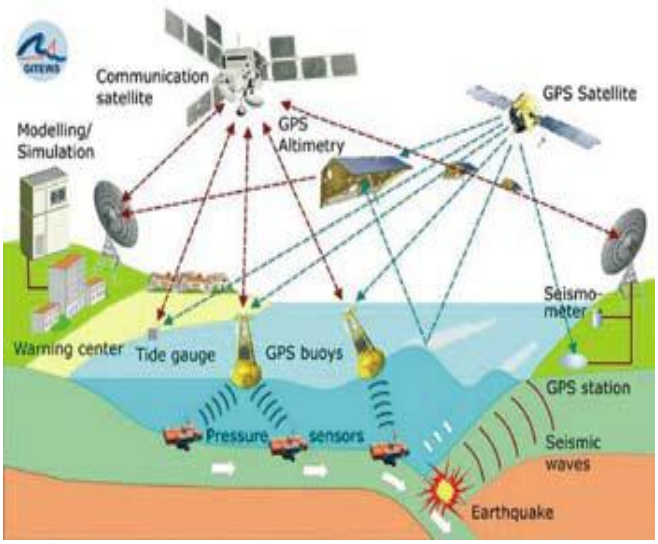
In this project, ICTs are supporting the ecological restoration of an important water source. This helps to reduce health risks associated with poor water quality and to ensure the continued availability of water from the dam's reservoir for irrigation, domestic water consumption and recreation. Healthy ecosystems are also widely acknowledged to provide a critical buffer against climate risks.

Early Warning, Weather Management, Satellite, Remote Sensing and Meteorological Systems

- **Distance Early Warning System for Tsunamis** (DEWS). This project, established by the EU after the 2006 Indian Ocean tsunami, is based on an open sensor platform (See Figure 3-4). It is used to monitor earthquakes (though seismic patterns), sea level (through tide gauges and buoys), ocean floor changes (though pressure sensors) and ground displacement (through GPS land station monitoring). Information from these sources is streamed via communication satellites to a central station in Jakarta, Indonesia for processing. Once it has been analyzed, information is disseminated by regional warning centres to different groups (using cellphones, SMS, landlines, fax, sirens and emails) in a form and language that each can understand.[183] Although the establishment of DEWS was motivated by a non-climate hazard—the risk of tsunamis—it contributes to stronger disaster response capacity in Asia and Africa. In addition, geospatial information gathered though the system (such as sea levels); forecasting and message composition components may be used to monitor changes due to climate change and to improve capacity to respond to climate-related hazards.

[183] DEWS, http://www.dews-online.org/c/document_library/get_file?uuid=8f7efd5b-d851-48c4-9fbb-28b7d925661c&groupId=10156, accessed August, 2011.

Figure 3-4: DEWS - Distance Early Warning System for Tsunamis[184]



Source: http://www.dews-online.org/documents/10156/10920/dews-a4-flyer-english-web.pdf

- **Satellite and remote sensing** – The number and range of remote sensing (RS) infrastructure and applications has continued to grow in Africa, though this is primarily located in a few countries (South Africa, Nigeria and Algeria).[185] Limited financial resources and the challenge of establishing strong academic and research bases have contributed to the slow uptake of remote sensing on the continent.[186] Box 3-1 illustrates the areas where remote sensing applications have been applied and some institutions that are involved in their use.

  There are a number of critical challenges which need to be overcome in enabling more effective decision-making and deployment of remote sensing for sustainable development. Africa has very limited experience of the installation of ground stations for acquisition and pre-processing of real-time satellite data.[187] A USAID review of remote sensing needs in Africa has highlighted the following difficulties:[188]

[184] DEWS, *ibid*
[185] Rochon, G.L. et al (2005). Applicability of near-real-time satellite data acquisition and analysis and distribution of geoinfromation in support of African development. UNECA. Retrieved from: http://repository.uneca.org/handle/10855/3129
[186] Rochon, G.L. et al (2005). *ibid*
[187] Rochon, G.L. et al (2005). *ibid*
[188] Rowland, J., Wood, E., Tieszen, L.L. (2007). Review of remote sensing needs and applications in Africa: Executive summary. USGS. From: http://edcintl.cr.usgs.gov/ip/Africa_RS_Review/RS%20Needs%20in%20Africa%20Exec%20Summary.pdf

- The landmass of Africa (24.2 M KmSq. In sub-Saharan Africa) makes the application of remote sensing technology more complex than in other continents – remote sensing data is based on size and cost. As a result, there is sparse or degraded ground-based earth science data.
- There is little experience or information in Africa of the use of geospatial technologies and little analysis of the African market for commercial satellite images.
- Access to data and to image processing software is restricted by cost and size.
- Although African bandwidth has continued to improve with the rollout of undersea cable infrastructure, bandwidth limitations restrict access to remote sensing data and applications, including those that are free.
- There is a shortage of skilled personnel to analyze and interpret data and to translate research outcomes into applications, although some initiatives have been developed to address this.[189]

Responses to these challenges should include the following:

- Remote sensing applications and data dissemination need to be well-defined and directed into specific and specialized areas such as those described in Box 3-1. Such categorizations will help in the allocation of resources to acquire specific applications and data, build specialized skills and expertise, and narrow gaps between research and application.
- There is a need to create a one-stop shop or portal for African geospatial data and images, which can bring together the various institutions, regional and national applications, and initiatives involved towards a central hub through which access to data and information can be maintained.
- Remote sensing facilities need to be extended beyond the technical community, while efforts are needed to translate technical data into appropriate information products. By developing mechanisms that allow other parties – such as the media, civil society and non-governmental organizations – access to geo-information and spatial research, the owners of facilities can contribute to extending knowledge use of data.
- Governments and public service departments should assume responsibility for providing remote sensing infrastructure including data infrastructure, acquisition, processing, archiving, launching of satellites and deployment of aerial systems.[190] They should subscribe to open data principles by providing access to remote sensing data and geo-spatial information.

[189] NOAA's Office of Global Programs, NASA's Applied Sciences program, and the Global Monitoring for Environment and Security program (GMES), funded by the European Space Agency (ESA) and the European Commission (EC).
[190] Rochon, G.L. et al (2005). Applicability of near-real-time satellite data acquisition and analysis and distribution of geoinfromation in support of African development. UNECA. Retrieved from: http://repository.uneca.org/handle/10855/3129

- Bandwidth and broadband access from and to Africa, and internally within individual countries, needs to be improved for regional and international coordination and sharing of data, and for access to high resolution and 3D images and applications. Capacity is also required on mobile networks to distribute images to end-users. More bandwidth will also enable access to free satellite images.
- To address capacity building concerns, partnerships between local and international research institutions may be required. Specific attention needs to be paid to research centers in post-secondary institutions and support is required for increased scientific research. Online tutorials on remote sensing such as those provided by NASA[191] should be tailored and repurposed for African needs, and systematically mainstreamed into capacity building initiatives.

[191] NASA provides a remote sensing tutorial at: http://rst.gsfc.nasa.gov/

Box 3-1: Remote Sensing Applications and institutions in Africa

Applications

African remote sensing data, information and applications have been used in many different sectors, including agriculture and rural development, climate and weather analysis, exploitation of natural resources, forestry, natural disaster and water resources management.[192] A scan of initiatives suggests that these can be categorized as follows:[193]

- Agriculture and rural development:
  - The Africover Project is a continent-wide land-cover assessment based on remote sensing and GIS techniques. It is supported by the Italian Government and initially concentrates on East and Central Africa. The overall goal of Africover is the development of a multi-purpose, digital, geo-referenced database on land cover and environmental information for use in early warning systems, forest and rangeland monitoring, catchments management, biodiversity and climate change studies at national and regional levels. The website provides web maps on Burundi, DR Congo, Egypt, Eritrea, Kenya, Rwanda, Somalia, Sudan, Tanzania and Uganda.[194]
  - The Global Information and Early Warning System on Food and Agriculture (GIEWS) combines with the Food and Agricultural Organization's (FAO) Real Time Environmental Monitoring Information System (ARTEMIX) to establish a crop monitoring system which uses near real-time satellite images (every 10 days, 8 kilometers resolution vegetation) to Africa[195] from the US NOAA polar orbiting satellite.[196]
  - GeoNetwork is an open source database initiative of the FAO which provides internet access to interactive maps, satellite imagery and related spatial databases required to support decision-making, promote multidisciplinary approach to sustainable development and enhance understanding of the benefits of geographic information.[197] FAO produces core datasets that are useful for monitoring, assessment and analysis of factors causing poverty, and food insecurity.
- Climate/Weather Analysis
  - UNEP's GRID-Arendal provides a set of 25 graphics that indicate temperature rise and adverse impacts spread across the diverse environment of Africa.[198] Graphics include wildlife, aridity zones, CO2 emissions and the El Niño-Southern Oscillation (ENSO) Phenomenon.
- Exploitation of Natural Resources
  - The Geomatics Committee of the International Association of Oil and Gas Producers is responsible for surveying, positioning and spatial data management activities that affect all areas of the exploration and production lifecycle in the oil and gas industry. The committee provides the EPSG Geodetic Parameter Dataset[199] and the Geospatial Integrity of Geoscience

[192] Rowland, J., Wood, E., Tieszen, L.L. (2007). Review of remote sensing needs and applications in Africa: Executive summary. USGS. From: http://edcintl.cr.usgs.gov/ip/Africa_RS_Review/RS%20Needs%20in%20Africa%20Exec%20Summary.pdf

[193] UNESCO (2007). Remote sensing applications. Available from: http://portal.unesco.org/ci/en/ev.php-URL_ID=22156&URL_DO=DO_TOPIC&URL_SECTION=201.html

[194] http://www.africover.org/

[195] http://www.fao.org/giews/english/giews_en.pdf

[196] http://www.fao.org/giews/english/giews_en.pdf

[197] http://www.fao.org/geonetwork/srv/en/main.home

[198] http://maps.grida.no/go/collection/vital-climate-graphics-africa

[199] http://www.epsg-registry.org/

Software (GIGS).[200] In response to the challenges resulting from difficulties in managing survey data, the OGP Seabed Survey Data Model (SSDM) Task Force was formed in 2010 to define a standard GIS data model for seabed survey.[201]

- Forestry
  - The Congo Basin Satellite Data Clearing House offered by the Central African Regional Program for the Environment (CARPE) provides a list of eight major sources of satellite data available to the Congo Basin,[202] including Landsat,[203] MODIS,[204] ASTER,[205] SPOT,[206] CBERS,[207] the Very High Resolution optical satellite imagery (which consists of Quickbird 2,[208] IKONOS,[209] Windowview 1+2,[210] GeoEye 1/Orbview 5,[211] RapidEye,[212]), Radar,[213] and LiDar.[214]
  - The Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is one panel within the Global Terrestrial Observing system (GTOS)[215] which provides ongoing space-based and in-situ observations of forests and vegetation cover at regional and global scales, to produce useful, timely and validated information products to a variety of users.[216]
  - The NASA Landsat Pathfinder Humid Tropical Deforestation Project of the University of Maryland maps global deforestation for the humid tropics in the Amazon Basin, Central African (Democratic Republic of Congo, Central African Republic, Cameroon, Congo, Gabon and Equatorial Guinea), and Southeast Asia using datasets from Landsat.[217]
  - Observatoire Satellital des Forêts d'Afrique Centrale (OSFAC) is an NGO in DRC with a regional mandate to promote the use of satellite data and products for the management of natural resources and sustainable development. It maintains a database of satellite imagery form Landsat, ASTER, SRTM, and Landsat Mosaics for the Congo Basin.[218]
  - The Southern African Fire Network is a regional network that fosters collaborative efforts in fire monitoring and management in Southern Africa. It delivers four data sets including the Advanced Fire Information System;[219] a Wide Area Monitoring System (WAMIS) which offers free access to various satellite imagery and products;[220] the PDA Animated Weather that contains real time images, graphics and text formatted for display on PDA devices equipped with high resolution color displays including composite weather radar and satellite images with graphical overlay of observed and predicted data;[221] and the MODIS Rapid Response

[200] http://info.ogp.org.uk/geomatics/ssdm.html
[201] http://info.ogp.org.uk/geomatics/ssdm.html
[202] http://carpe.umd.edu/resources/satellite_data_clearinghouse.php
[203] http://landsat.gsfc.nasa.gov/
[204] http://modis.gsfc.nasa.gov/
[205] http://asterweb.jpl.nasa.gov/
[206] http://www.spotimage.com/web/en/224-technical-information.php
[207] http://www.cbers.inpe.br/?hl=en
[208] http://www.digitalglobe.com/about-us/content-collection#satellites&quickbird
[209] http://www.geoeye.com/CorpSite/products-and-services/imagery-sources/
[210] http://www.digitalglobe.com/about-us/content-collection#satellites
[211] http://www.geoeye.com/CorpSite/products-and-services/imagery-sources/
[212] http://www.rapideye.de/products/images.htm
[213] http://ccrs.nrcan.gc.ca/resource/tutor/fundam/chapter3/08_e.php
[214] http://lidar.cr.usgs.gov/
[215] http://www.fao.org/gtos/index.html
[216] http://www.fao.org/gtos/gofc-gold/index.html
[217] http://www.geog.umd.edu/tropical/abstract.html
[218] http://osfac.umd.edu/dataproducts.html
[219] http://afis.meraka.org.za/
[220] http://afis.meraka.org.za/wamis/
[221] http://www.ssec.wisc.edu/data/paw/

system which provides daily images in near real time by geographic regions and a Web Mapping Service.[222]

- The Tropical Forest Mapping Project in Africa is a study of land-use and deforestation in the Central African tropical forest using High Resolution SAR satellite imagery acquired by JERS-1 SAR (Synthetic Aperture Radar).[223]

- Natural Disaster Management
  - ReliefWeb provides time-based timely, reliable and relevant critical humanitarian information on complex emergencies and natural disasters to assist the international humanitarian community in effective delivery of emergency assistance[224] using a visualization tool called Mapbox.[225]
- Water Resources Management
  - The TIGER Africa initiative was launched in 2002 following the Johannesburg World Summit on Sustainable Development by the European Space Agency to focus on the use of space technology for water resource management in Africa.[226]

Initiatives such as Africover described earlier and SERVIR Africa address a broad base of areas including disasters, ecosystems, biodiversity, weather, water, climate, oceans, health, agriculture, and energy. Servir Africa integrates satellite observations and predictive models with data from sensors and field based geographic information to monitor and forecast ecological changes.[227] These systems are used to improve scientific knowledge and to enhance decision making.

Institutions

There are a number of continental, regional and national institutions, organizations, initiatives and networks involved in geospatial data and information analysis and destruction in Africa.

- Application of Remote Sensing for Integrated Management of Ecosystems and Water Resources in Africa (ARSIMEWA) enables twelve African countries[228] to access and use satellite data, the internet and ICTs to monitor, assess and manage ecosystems and water resources; and to improve environmental management and decision making that leads to sustainable development.[229] [230] Its objective is to improve the ability and capacity of African countries to access and use remote-sensed data; forge sub-regional, south/south, and north/south remote sensed data transfer cooperation; and bridge the gap between the north and south.[231]
- The African Association of Remote Sensing of the Environment (AARSE) was formed in 1992 by the United Nations and the government of the United States to address gaps in human capacity and those that were evident between resource and environmental management and their depletion.[232] It seeks to achieve this through capacity building, workshops, seminars and conferences, and research that promote the appreciation of technology including remote sensing and GIS applications and

[222] http://lance.nasa.gov/imagery/rapid-response/
[223] http://www-radar.jpl.nasa.gov/africamap/proj_sum.htm
[224] http://portal.unesco.org/ci/en/ev.php-URL_ID=19105&URL_DO=DO_TOPIC&URL_SECTION=201.html
[225] http://reliefweb.int/countries#show
[226] http://www.tiger.esa.int/
[227] http://www.servir.net/africa/index.php?option=com_content&task=view&id=26&Itemid=46
[228] Benin, Botswana, Cote d'Ivoire, DRC, Equitorial Guinea, Guinea, Mozambique, Niger, Nigeria, Senegal, South Africa, and Zimbabwe.
[229] http://portal.unesco.org/ci/en/ev.php-URL_ID=2174&URL_DO=DO_TOPIC&URL_SECTION=201.html
[230] http://portal.unesco.org/ci/en/ev.php-URL_ID=18077&URL_DO=DO_TOPIC&URL_SECTION=201.html
[231] http://portal.unesco.org/ci/en/ev.php-URL_ID=18077&URL_DO=DO_TOPIC&URL_SECTION=201.html
[232] http://www.itc.nl/aarse/aboutus.html

cooperation between institutions.

- Regional remote sensing centres have been created in the continent, including the following:[233]:
  - The AGRHYMET Regional Center (ARC) in Niamey, Niger.[234] This was established in 1975 by the UNECA and the AU to promote the development and use of geo-information through the provision of standardized digital databases on land resources and a regional early warning system based on satellite technology for food security, environmental monitoring and disaster management. It provides aerial photos and satellite images from NOAA and METEOSAT, of rainfall animation, lake and pasture monitoring; and mapping of road networks, forests, and soils, crop monitoring and watering points.
  - The Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya was also established in 1975 by the UNECA and AU as a premier center of excellence in the provision of geo-information and information technology services in environmental and resource management to its 18 contracting member states in Eastern and Southern Africa.[235] The center provides an archive of LandSat data from 1972 and is a reseller of images and data from QuickBird, WorldView, GeoEye 1/2, Ikonos, Orbview Imag-ery, SPOT Image (SPOT 2.5m, SPOT 5m & SPOT 10m), USGS (Landsat MSS, and Landsat TM & Landsat ETM+).[236]
  - The Southern African Development Community (SADC) Regional Remote Sensing Unit (RRSU) in Gaborone, Botswana) facilitates training programmes and technical support in the field of remote sensing, agro-meteorology and GIS in support of early warning for food security, natural resources management and disaster management.[237] It maintains a database of satellite images and vector datasets for SADC countries with various resolutions from METEOSAT, NDVI (LACéGAC), SPOT-4 VGT, MODIS, LANDSAT, and ASTER;[238] and a regional GeoNetwork node for access to more datasets.[239]

3.2 The role of ICTs in climate risk management

Before communities can be effectively supported in adapting to the impact of climate change, it is critical to identify what changes are taking place and their implications for lives and livelihoods. Having done this, it is then possible to identify ways in which societies, communities and their economic and other structures can be adapted to secure better outcomes for lives and livelihoods. Such adaptations may be defensive, concerned primarily with reducing risk, or they may be progressive, concerned with adapting in order to take advantage of new opportunities. At the core of this challenge, however, is the need to manage climate risk. ICTs can, and do already, play a part in this process. The need to account for changing climate patterns in mainstream planning and decision-making will also grow as changes continue to occur in local and regional climates.

[233] Rowland, J., Wood, E., Tieszen, L.L. (2007). Review of remote sensing needs and applications in Africa: Executive summary. USGS. From: http://edcintl.cr.usgs.gov/ip/Africa_RS_Review/RS%20Needs%20in%20Africa%20Exec%20Summary.pdf
[234] http://www.agrhymet.ne/eng/
[235] Countries include: Botswana, Burundi, Comoros, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Namibia, Rwanda, Seychelles, Somalia, South Africa, Sudan, Swaziland, Tanzania, Uganda and Zambia.
[236] http://www.rcmrd.org/index.php?option=com_content&view=article&id=68&Itemid=64
[237] http://www.sadc.int/fanr/aims/rrsu/
[238] http://www.sadc.int/fanr/aims/rrsu/database.php
[239] http://www.sadc.int/geonetwork/srv/en/main.home

The governments of African countries are aware of the growing need to mainstream climate risk into their development activities. As discussed in Chapter 2, governments have highlighted a number of critical adaptation needs, including better early warning of climate hazards such as droughts and floods, monitoring of vector-borne diseases, dissemination of agro-meteorological information to farmers, and greater understanding of climate change and its risks by the public and government officials. As also noted in Chapter 2, on-going projects in Africa are using ICTs to:

- generate, organize and communicate information on the risks resulting from climate variability, climate change and extreme climatic events;
- prepare for and ameliorate these risks for food security and water supply; and
- develop early warning systems and maps of vulnerable areas and impacts of climate change.

This section of Chapter 3 explores in more depth how practical applications of small- and large-scale ICTs are being used to improve understanding of climate risks and take steps to ameliorate these.

3.2.1 Small-scale applications

Small-scale applications of ICTs—*i.e.* low-tech ICTs tools and knowledge communication tools – are being used in a variety of ways to understand and manage current climate variability and the longer term risks associated with climate change. The following paragraphs illustrate some examples of such projects.

Low-tech ICT Tools

- **Kilimo Salama.** This Kenyan program enables small-scale farmers (some of whom farm less than an acre of land) to obtain micro-insurance against drought or excess rain. Farmers pay an additional 5 percent on top of the cost of a bag of improved seeds, bag of fertilizer or other input purchased from a participating, registered agro-dealer. These local agro-dealers have been trained to use a camera phone to scan a barcode on each purchase, which automatically registers the policy with UAP insurance using Safaricom's mobile data network. An SMS message is then sent to the farmer's mobile phone to confirm purchase of the insurance premium. An insurance payout is triggered if data transmitted from one of thirty weather stations over Safaricom's 3G data network indicates that "drought or other extreme conditions (including excessive rains) are destined to cripple crops." Farmers registered with each of the weather stations providing this information "automatically receive payouts directly via Safaricom's M-PESA mobile money transfer service." Kilimo Salama was initiated by the Syngenta Foundation

for Sustainable Agriculture, UAP Insurance and Safaricom.[240] It is one of a growing number of weather-based insurance schemes around the world.

- **Using Radio TV Drama to Adapt to Climate Change.** In northern Nigeria, radio drama has been used to enhance learning and dialogue in farming communities coping with climate change. The content of drama segments has been developed using information from focus groups, literature reviews and Nigerian agricultural institutions, as well as a workshop focused on determining the most important messages that need to be understood in target communities. At the end of each episode, the radio host highlighted local initiatives, provided farmers with contact information for local climate change organizations, and encouraged listeners to provide feedback through text messages, phone, email or farmers' groups. The drama aired weekly on seven radio stations.[241]

In addition to these examples, mobile phone applications are being used to provide seasonal forecasts (usually three and six months ahead of time) to target recipients. Farmers in developing countries, who tend to rely on traditional knowledge for their agricultural practices, are increasingly being challenged by greater weather variability. Frequent seasonal forecasts can help them to adjust their farming practices (such as planting cycles) in the light of changing weather and climate circumstances.

Knowledge Communication Tools

- **The Open Risk Data Initiative.** The sharing of climate hazard and risk data is critical to effective disaster risk management, but its practical implementation faces a number of barriers. One of these is the lack of simple, affordable tools to enable data-sharing. To address this and other barriers,[242] the Global Facility for Disaster Reduction and Recovery's Open Risk Data Initiative provides a rationale, technical assistance and tools to support data-sharing. Activities include extending open source software tools to participating countries and launching a global data-sharing platform to make information available to the public.[243]

- **Climate Change Explorer Tool.** This tool provides users with an analytical foundation from which to explore the climate variables relevant to their particular adaptation decisions. The approach makes crucial links between understanding vulnerability, monitoring and projecting climate hazards and planning adaptation processes. It is grounded in several critical assumptions concerning the interpretation of climate science. The Tool provides an

[240] ScienceDaily (2010, March 4). Micro-insurance plan uses mobile phones and weather stations to shield Kenya's farmers. Accessed from http://www.sciencedaily.com/releases/2010/03/100304202242.htm.
[241] AfricaAdapt ([2009]). Radio Dramas for Strengthening the Capacity of Smallholder Farmers to Adapt to Climate Change. Retrieved from: http://www.africa-adapt.net/aa/ProjectOverview.aspx?PID=hYdkMdcb9KU%3D
[242] Other barriers are the "absence of recognized standards and best practices related to sharing; nascent awareness and understanding of the importance and economic value of sharing data; misaligned institutional incentives precluding the sharing of data; and inadequate technical expertise" (GRDRR: https://www.gfdrr.org/gfdrr/sites/gfdrr.org/files/OPEN%20RISK%20DATA%20INITIATIVE.pdf).
[243] Open Risk Data Initiative, https://www.gfdrr.org/gfdrr/sites/gfdrr.org/files/OPEN%20RISK%20DATA%20INITIATIVE.pdf

interface to download, manage and visualize downscaled model output. Services provided by it include access to downscaled, station-level response to Global Circulation Model output for Africa and Asia, and analysis and visualization of climate data such as summary statistics from selected weather stations, seasonal charts, frequency histograms and climate envelopes.[244]

3.2.2 Large-scale applications

Climate risk management, whether it is focused on problems that arise from climate variability or climate change, often relies on large-scale ICT applications such as GIS, modelling, planning and decision tools, smart systems and sensor networks, and early warning, weather management and meteorological systems. The following paragraphs describe indicative examples of these applications.

GIS, Global Positioning Systems and modeling

Climate modelling is one of the most significant potential areas in which ICTs can support the management of climate risk. Information technology, in the original sense of the word, involves the use of computers to analyse data and develop large-scale strategies. Although it is sometimes easy, in today's age of rapid change in communications, to overlook the significance of traditional computing solutions, ICT-enabled computer modelling is essential for effective analysis and design of responses to climate change. This is particularly true in developing countries, where a lack of accurate information and data on climate change is (rightly or wrongly) still seen as one of the primary barriers to implementation of adaptation actions.

Examples of current applications of GIS and modelling in climate risk management include the following:

- **The South African Risk and Vulnerability Atlas.** This electronic spatial database directly supports access to and visualization of data about the impact of global change (including climate change) on human and natural environments. With funding from the South African Department of Science and Technology, the Atlas initiative provides access to a large collection of scientific data and knowledge, including climate and weather related datasets. These datasets include forecasts of rainfall, wind and temperature, seasonal forecasts, and climate change projections for rainfall, temperature and circulation. Case studies are also accessible through the website. These highlight the preparation of maps in different parts of South Africa where there is a high level of risk to water availability due to climate change.[245]

[244] Accessible at: http://wikiadapt.org/index.php?title=The_Climate_Change_Explorer_Tool; Source: The Climate Change Explorer, an introduction (n. d.)
[245] South African Risk and Vulnerability Atlas website: http://rava.qsens.net/

- **PRECIS Regional Climate Modelling System.** Other large-scale tools include global and regional circulation models, of which PRECIS (Providing Regional Climates for Impact Studies) is an example. Developed by the UK Met Office's Hadley Centre, this regional climate modelling system is "designed to run on a Linux based PC and can be easily applied to any area of the globe to generate detailed climate change projections." PRECIS was developed specifically to help make freely available high-resolution climate change information to groups in developing countries, and thereby to support the development of climate change scenarios and the completion of impact, vulnerability and adaptation studies. It has been used in studies of future climate throughout the world, including in Ethiopia and Malawi.[246]

Smart systems and sensor networks

Smart sensor networks provide excellent opportunities to collect data that can be used to improve response rates and reduce the time required for adaptation action. A collection of small computers equipped with sensors transmits information over wireless networks in real time to a central hub, which can then forward it to a central database using the Internet. Sensor networks are not new, but they are increasingly being used in the monitoring of weather patterns and other climatic conditions.[247] Examples of their application include the following:

- **Wireless Sensor Networks for Environmental Management.** Land in Springbrook National Park, Australia, is being restored from agricultural grassland to native rainforest vegetation. The location is a high rainfall environment that includes a wide range of different environmental factors or environmental gradients. A wireless sensor network comprising fifty sensor nodes and more than 200 individual sensors has been deployed in Springbrook to monitor temperature, humidity, rainfall, light, leaf wetness, soil moisture, wind speed and wind direction (See Figure 3-5)). As at February 2011, final preparations were underway to deploy an additional 125 sensor nodes to collect information on tree growth, carbon dioxide concentrations, cloud cover and fog density. A further 175 nodes will subsequently be deployed to monitor bio-acoustic sounds and video. The completed system will track restoration of the park's biodiversity and provide insights into how the micro-climates and biodiversity of the Springbrook plateau change over time.[248]

[246] PRECIS, http://www.metoffice.gov.uk/precis/

[247] Sensor networks are used in the area of environmental monitoring to gather information such as light, rainfall, fog sensors, carbon dioxide and water quality, and can communicate up to a distance of 500 metre. Sensor networks can also generate sound, images and video in the area of water quality, agriculture, satellite remote sensing, forestry, horticulture and climate change. More recent uses include monitoring of wind speed and direction, rainfall, temperature, humidity, barometric pressure, leaf wetness, soil moisture, soil water potential, photosynthetically active radiation, total solar radiation, tree diameter (growth rate), and sap flow in trees (water use). (Source: Queensland Environment and Resource Management (no date). Wireless Sensor Network Springbrook. Retrieved September 2011 from http://www.derm.qld.gov.au/wildlife-ecosystems/plants/queensland_herbarium/wireless_sensor_network_springbrook.html)

[248] Source: Queensland Environment and Resource Management (no date). Wireless Sensor Network Springbrook. Retrieved September 2011 from http://www.derm.qld.gov.au/wildlife-ecosystems/plants/queensland_herbarium/wireless_sensor_network_springbrook.html

Figure3-5: Springbrook Wireless Sensor Networks

Source: http://www.derm.qld.gov.au/wildlife-ecosystems/plants/queensland_herbarium/publications/images/wirelss_wsn.jpg

- **Monitoring Glacial Lakes in the Himalayas through Sensor and Wireless Technology**. In the Himalayas, warming temperatures are leading to increased melting of glaciers, the expansion of glacial lakes, and greater risk of glacial lake outflow bursts causing flash floods downstream. In response to this threat, a pilot project has been undertaken in which a field server (a sensor) and wireless network were established to monitor the Imja glacial lake in real time. This pilot scheme collected data concerning air temperature, humidity, solar radiation, carbon dioxide and water levels, as well as photographic and video information. The collected data were relayed for analysis at the National Agriculture Research Centre in Japan before being transmitted back to

Nepal.[249] Monitoring systems such as this can help to reduce the risk of flash floods and can also track the observed consequences of climate change.

Early Warning, Weather Management, Satellite, Remote Sensing and Meteorological Systems

- **Bell and Bottle: A Low-Cost System for Flood/Landslide Prone Communities.** In the Philippines, climate change is expected to lead to heavier rainfall in locations that are already prone to floods and landslides-. To reduce the risk which extreme events pose to local lives and livelihoods, an innovative, fast, low-cost early warning system has been introduced, based upon the use of bottles and bells. The project uses remote sensing to identify particularly vulnerable locations. Members of communities in these areas are then given soda bottles with which to measure rainfall. Once the water within these bottles reaches predetermined levels, warning alerts of the potential for flood or landslide are given by the ringing of bells. Developed jointly by the Farming and Soil Resources Institute of the University of the Philippines at Los Baños and the Center for Initiative and Research for Climate Adaptation, with funding from the World Bank, this system provides early warning to 15 to 20 villages (benefitting between 12,500 and 17,500 people) using 50 bells and hundreds of bottles.[250]

- **The Community Flood Information System (CFIS)**[251] is another flood warning system, this time used in Bangladesh to warn communities of the imminence of floods, whose presence helps those communities to adjust their adaptation strategies. Messages of flood intensity represented by pluses (+) and minus (-) are conveyed using SMS. The following story from one beneficiary of the System illustrates its value:

> *I am Anser Ali Molla, one of the registered mobile users under the CFIS project who received early flood warning through SMS directly and shared the information. I feel proud to perform such a duty. One day, during the recent flood, I saw my neighbor, Niranjan Rajbangshi, preparing to build a new room on low land next to a channel adjacent to his house. That day I received a flood warning of "+ +". That meant water might increase one hand (approximately 50 cm) in the next two days. I anticipated that the bank of the channel might be breeched if the level of water increased by one hand. If the canal bank breeched, Niranjan's room would be destroyed, so, I convinced him not to build the room during monsoon, and he agreed.*[252]

[249] Shrestha, B.J. and P. Manandhar (2009). Monitoring Glacial Lake in Himalayas through Sensor and Wireless Technology: An application in climate change. Presentation made at the 28th APAN Meeting, 20 to 23 July, Kuala Lumpur, Malaysia. Retrieved September 2011 from http://www.apan.net/meetings/kualalumpur2009/proposals/Agriculture/APAN_Malaysia.pdf
[250] Sources: http://siteresources.worldbank.org/DEVMARKETPLACE/Resources/205097-1234488846479/3191.pdf and http://www.flickr.com/photos/devmarketplace/4100968967/
[251] USAID (2008). *Community Flood Information System.* USAID. From: http://pdf.usaid.gov/pdf_docs/PDACL719.pdf
[252] USAID (2008). *Ibid*

3.3 Observations on the existing use of ICTs to support adaptation

The examples of ICT applications described in sections 3.1 and 3.2 provide a glimpse of the current and potential future applications of ICTs in support of adaptation to climate change. They are intended to serve as illustrations. Additional examples of applications which are currently being used are presented in Table 3-1. Further examples of applications currently in use emerged during field visits to Malawi, Senegal and Uganda which were undertaken for this report and which are described in Chapter 4. These tools include participatory GIS applications used to map potentially vulnerable areas and address immediate and future water requirements, and AfricaAdapt, a knowledge platform designed to promote knowledge-sharing and -management.

A review of these applications suggests that their current use is mostly directed towards:

- early warning;
- information-sharing about climate change impacts and adaptation options; and
- managing and providing access to weather data and seasonal forecasts (especially in the context of agricultural production).

In particular, ICTs are providing individuals and communities with information, communication and knowledge resources that can help to inform adaptation decision-making. They are also enabling the monitoring, measurement and management of natural, human and built environments through remote sensing, embedded sensor networks, radio-frequency identification (RFID) and other networking and monitoring technologies.

Climate-risk-related applications often combine early warning, meteorological and water management systems, GIS-based tools and the use of ICTs such as mobile phones to check situations in the field, collect data about consequences and disseminate information. An important element of these opportunities, therefore, is the extent to which they can combine high-level data with local inputs, thereby verifying the validity or otherwise of policy and practice. Through them and their effective use, the uncertainties that are part of current climate forecasts and future climate projections can be reduced, particularly those concerned with severe rainfall, flash floods and other extreme weather events.

These uncertainties could be further reduced if current limitations on information available to inform climate change projections and impacts in Africa were addressed. These limitations include insufficient coverage by weather stations (particularly in the Central and Horn of Africa regions, where their density is one eighth of that recommended by the World Meteorological Organization.[253] Projections and impact

[253] Conway (2009).

studies are needed to guide the development of adaptation response strategies in the next and future decades. Investment in the monitoring of hydro-meteorological and socio-economic trends to help validate climate change models and impact projections is expected to play a large part in the use of ICT tools to support climate change adaptation, together with the translation of information derived from them into formats that are useful for a diverse range of sectoral experts and other users. Investments of this kind will need to be supported by capacity-building and training of personnel able to generate, analyze and translate information for use in decision-making.

Table 3-1: Overview of key ICT tools in the literature focused and/or relevant for adaptation to climate change

ICT Tool type/Category and a brief overview (*Information systems on climate change at local, regional and global levels)*
Early warning Systems/Weather Management/MET Systems
• Extreme weather information dissemination in India: an integrated knowledge-system on climate change adaptation uses traditional and new media, Web 2.0, Internet and mobile phones to facilitate community access to locally relevant knowledge, helping locals to better adapt within a context of high vulnerability to extreme weather events and food insecurity.[254] Small ICTs/Mobile Phone Applications/General Packet Radio Systems. • Regional climate change scenarios using the PRECIS system: INSMET has been producing regional climate change scenarios for the Caribbean using the PRECIS system. More information is available on their website.[255] • MapAction: works in disaster zones providing frequently updated situation maps showing where relief help is most urgently needed. The UK-based company was established in 1997. In a humanitarian crisis, relief agencies need rapid answers to questions about 'where'. For example, where are the greatest needs or where are the gaps that need to be filled?[256] • Satellite Technology Available to Aid Relief Workers in Guyana, Caribbean: Relief workers in Guyana and the Caribbean can now access geographic data about displaced persons or downed infrastructure during disasters with the recent launch of MapAction Latin American and the Caribbean (MapLAC), a newly established arm of MapAction. When disasters strike, coordinating relief efforts hinge on the rapid transfer of situation information. MapLAC can deliver that information in the form of maps created and distributed in the field, greatly aiding the delivery of rescue, response and aid. It shows for instance, displaced people, damage to buildings, downed bridges, road and rail disruptions, and newly established food depots or hospitals can all be displayed on the GIS image.[257] • Community monitoring in flood protection: In the Lower Mekong Basin (Vietnam), Vietnamese villagers were provided with mobile phones and training in order to respond more effectively to the 2008 flood season, using the technology to report the likelihood of localized flooding to the Southern Region Hydro-Meteorological Center in Ho Chi Minh City – the local agency responsible for flood forecasting. Measurements taken twice a day by locals were sent via SMS to the responsible authorities, facilitating greater accuracy and more precise flood warnings to communities. Based on this information, they could better prepare for evacuations, and protect their livestock. Additionally, long-term flood patterns based on the information gathered will help better plan local irrigation systems and decide on crop diversification strategies.[258]
Environmental Information Systems
• Mobile to mobile-enabled water management devices are used to monitor soil water content and optimize crop growing conditions. Such systems assess and control irrigation on a just-in-time basis, using weather information and water evaporation, plant transpiration and sub-soil leakage data. • In 2007, India launched the National Tsunami Early Warning System which uses SMS messages as one of its ways to alert the public (See Chapter 4).

[254] BCO (2010a)
[255] *Adapted from Cuba Met Service* http://www.met.inf.cu/asp/genesis.asp?TB0=PLANTILLAS&TB1=INICIAL Source: Tandon(2009)
[256] *Adapted from MapAction,* http://www.mapaction.org/
[257] *Source: Adapted from Stabroek News, November 2007,* Tandon(2009)
[258] MRC (2009), in Tandon (2009)

- In 2007 the Joint Research Centre of the European Commission launched mobGAS, a mobile phone application available in 21 European languages that allows users to see how their daily choices are impacting on climate change by compiling information inputted by users, for example, on how they regulate their heating, what means of transport they take and the household appliances they use.

Geographic Information Systems/Modelling/Planning/ Decision tools

- Mapping malaria risk in Africa by using GIS mapping tools. Such systems assess and control irrigation on a just-in-time basis, using weather information and water evaporation, plant transpiration and sub-soil leakage data.[259]
- GIS, positioning and modelling applications in mangrove management and rehabilitation in Kenya: ICTs used to strengthen the physical preparedness of livelihood systems for climate change related events. These contribute to design of defences and determination of their optimal location; both making the livelihood system more robust. Remote sensing and GIS technology have been used to map and then rehabilitate and sustainably manage mangrove forests in Kenya.[260]
- Studying rainfall patterns on marginal lands in Southern America to adjust crop production: Favourable rainfall patterns over the past 20 years, in South America's southern cone (Brazil, Bolivia, Chile, Uruguay, and Paraguay) have allowed formerly marginal lands to grow crops. Such climate changes have led to significant agricultural shifts with the region becoming one of the most important producers of staple crops such as corn, wheat, and soybeans. Researchers assert that by studying how climate change can alter rainfall, we will have a better understanding of the nature and magnitude of the current and future risks that threaten farming and other livelihoods in the region. This information will also inform what technologies, production systems, and water resource management practices are available to people to help reduce those risks.[261]

Knowledge Management/Information Sharing Systems

- AfricaAdapt is an independent bilingual network which aims to facilitate the flow of climate change adaptation knowledge for sustainable livelihoods between researchers, policy makers, civil society organisations and communities which are vulnerable to climate variability and change (see Chapter 4).
- Village Resource Centres in India have enabled rural clients to interact with scientists, doctors, experts and government officials in urban locations.
- Community-Based Adaptation Exchange (CBA-X) is an example of an online community of practice designed to support national strategies of adaptation and evidence-based policy making. Based on a Facebook style social networking tool, users are encouraged to share publications and advertise jobs and events. The community platform allows for linking to friends, creating/joining sub-groups, providing detailed profiles, uploading files and writing blogs.[262]
- Using Radio TV Drama to Adapt to Climate Change (Nigeria). Information from focus groups, literature review and Nigerian agricultural institutions has helped to provide content for radio drama segments. At the end of each episode of the series, the radio host highlights local initiatives and provides farmers with contact information for local climate change organizations.[263]

Small ICTs/Mobile Phone Applications/General Packet Radio Systems (GPRS)

- Mobile Phones to inform adaptive behavior (Tanzania). Mobile phone and Internet use by small-scale

[259] Feek W. (2003) The Digital Pulse. The Current and Future Applications of Information and Communication Technologies for Developmental Health Priorities. A Report Published by The Communication Initiative, pp.217; MARA website at www.mara.org.za

[260] Kairo et al. (2002), Ospina and Heeks (2010b)

[261] Tandon(2009)

[262] Part of Eldis-Institute of Development Studies (IDS), in collaboration with the International Institute for Environment in Development. Eldis is funded by SIDA, NORAD, DFID, and SDC; Paas and Parry (2011)

[263] Sources: Adapted from the African Radio Drama Association, http://ardaradio.org/whats_new_at_arda and Canada's Coalition to End Global Poverty, http://www.ccic.ca/f/docs/003_food_2009-03_case_study_nigeria.pdf; Tandon(2009)

farmers was found to increase their participation in markets and provide information for improved productivity. This should increase disposable income, which may then be used to strengthen local preparedness and response to climate events (*e.g.* buying additional food to store, or improving the building structure of the household).[264]

- Mobile applications – for example job-seeking resources such as Babajob, which uses web applications and mobile technology to connect informal sector workers (maids, cooks, drivers, *etc.*) with potential employers in India.[265]
- The use of m-commerce systems such as those offered in the Philippines by SMART Padala, through which users can make purchases from a variety of participating retailers. This allows these retailers to extend their business operations beyond their local areas.[266]
- Use of iPods to help disseminate information about agricultural practices: In Uganda, iPods and podcasts are being used in marginalized communities to access creatively packaged content relevant to their livelihoods. Content includes information on improving agricultural productivity (seeds, crops or livestock breeds, importance of livestock vaccinations and preventative health management, information on small-scale machinery), best practices to adapt to climate change (e.g. alternatives to costly chemical fertilizers and pesticides, appropriate agrochemical use), as well as awareness on the importance of collaboration via associations for bulk trading to more effectively brand and negotiate small quantities of produce.[267]
- Combining Web 2.0 tools with local knowledge to build a clearer picture of climate change (global - private sector). An online tool that looks at the impacts of climate change in certain areas, and enables distribution of seasonal weather forecasts looking six months ahead and tailored for farmers in specific locations.[268]

3.4 Challenges

Alongside these opportunities, the literature review, online survey and other data gathered for this study[269] have made it possible to identify a number of challenges related to the use of ICTs to support adaptation.

One fundamental challenge concerns the limited **conceptual understanding** amongst researchers and policy-makers concerning the role that ICTs might play in supporting adaptation. As discussed in Chapter 1, explorations of the contribution that ICTs can make to adaptation are still new. The absence of established frameworks and of a clear understanding of the interface between ICTs and climate change limits the capacity of relevant professionals to explain to policy-makers how and why investment in

[264] Lightfoot *et al*., (2008) in Ospina and Heeks, (2010b)
[265] Ospina and Heeks (2010b)
[266] Wishart, (2006) in Ospina and Heeks (2010b)
[267] ALIN, (2010)
[268] Adapted from ICT Update, http://ictupdate.cta.int/en/Feature-Articles/A-climate-mashup; Tandon(2009)
[269] The survey titled, "eTransform Africa: ICTs and Climate Change Adaptation" was disseminated in June 2011 and widely distributed through research networks, national mailing lists and snow balled from climate change practitioners. The survey was available at: https://www.surveymonkey.com/s/climatechangeafdb. The response rate may not be taken as representative and therefore findings are not generalizable; however, as the respondents were practitioners and therefore provided evidence of their practice on the ground, it is a useful outcome of the process. Respondents who identified their countries of residence came from Bangladesh (1), Benin (1), Cameroon (1), Canada (2), Central African Republic (1), Germany (1), Malawi (2), Senegal (1), Taiwan (1), Uganda (3) and the United Kingdom (1). Details of the survey can be found in Appendix 5.

improved ICT infrastructure and services might contribute to reducing vulnerability to climate change. By extension, this limits the promulgation of appropriate policies that can help governments to frame their ICT interventions in the area of climate change and adaptation—particularly when priorities are focused on what are (or are perceived to be) more pressing needs.[270]

At the same time, it should be recognised that ICT professionals have generally limited understanding of climate change and related issues. The two fields are not well connected either technically or in policymaking terms. It has proved difficult to raise awareness of ICTs in fora like the UNFCCC. At the same time, as in other areas of ICTs and development, there is a risk that technology specialists will overestimate the potential for ICTs to transform complex situations, and underestimate the challenges posed by poor infrastructure, limited financial and human resources, and the uncertainties that surround our understanding of climate change, its present and likely future impacts, and the effectiveness of different strategies for mitigation and adaptation.

A further, related, challenge concerns varying expectations of the role of the **public and private sectors** in adaptation and in the development of ICTs. Generally speaking, the public sector is expected to play a significant role in setting the enabling conditions for adaptation—by removing policy barriers, building capacity through the education and health systems, and making available information needed for decision-making—and in financing adaptation through investments in infrastructure, research and development, and in monitoring systems.[271] Engagement of the private sector in adaptation (as opposed to mitigation[272]) is still relatively limited, both globally and in Africa. For example, respondents to the survey for this study observed that, although they understand that the private sector could play a significant role in climate change adaptation, there is limited perception of how this might come about. While efforts are underway to remedy this situation,[273] the private sector remains poorly involved in adaptation efforts (with some significant exceptions such as the insurance and reinsurance sectors).

By contrast, the private sector has been extremely active in developing Africa's ICT sector. The growth of ICT technology, services and markets, particularly mobile telephony, has been made possible by private sector funding, itself enabled by the on-going process of privatization and trade liberalization that has

[270] Comments from Petrus Venter, Program Leader at Harties Metsi a Me (My Water) project, Pretoria, South Africa, on July 8, 2011.

[271] As stated by the Institutional Investors Group on Climate Change, "It is still much less clear how the developing world's enormous need for finance for climate change adaptation can be translated on a large scale into investment opportunities that generate returns that are attractive to institutional investors. While it is reasonable to envisage large-scale private sector investment in mitigation in developing countries if policy frameworks and other conditions are right, it is likely that adaptation will have to be financed primarily by the public sector for the foreseeable future." Source: IIGCC (2009). Non-Carbon Market Financing Mechanisms for Climate Change Mitigation and Adaptation in Developing Countries. Available from http://www.iigcc.org/__data/assets/pdf_file/0012/462/IIGCCFinancingMechanisms.pdf

[272] The private sector plays an active role in efforts to reduce emissions of greenhouse gases, such as through market mechanisms like the Clean Development Mechanism and the European Union Emissions Trading System, and through investment in renewable energy technologies, energy efficiency systems, more efficient vehicles, etc.

[273] Examples include the UNEP Finance Initiative, micro-finance and weather-based index insurance.

encouraged almost all African governments to create a positive environment for investment in the sector. Whether this historical involvement in the ICT sector can be channelled into enabling adaptation is far from clear, however, as adaptation currently lacks the potential for rapid returns on investment that lay at the heart of private sector commitment to ICTs.

It is noteworthy that participants in the interviews and survey conducted for this study typically spoke of the government's role in supporting the use of ICTs in adaptation. Government was perceived as being the initiator of infrastructure development and capacity-building programs, as well as efforts to provide technical know-how and to address the information gaps facing communities (particularly in rural areas). Few respondents suggested that the private sector should have a role in investments in infrastructure development for adaptation. These findings reflect the predominance of the state and external donors in funding infrastructure in Africa since independence, in contrast with the experience of other world regions. They also suggest that there may be a desire for governments to take a more proactive role in enabling ICTs support of adaptation, including the development of a mechanism through which the private sector could provide additional support. However, barriers to public-private investment in ICTs that facilitate adaptation are evident, such as the lack of an appropriate policy environment and the potential conflict between environmental and commercial interests. These barriers will need to be overcome if broader public-private participation mechanisms are to be established that support adaptation to climate change.

Technical and infrastructure challenges are also significant factors impeding the effective application for ICTs in supporting adaptation. Marginalized and poor populations—often located in remote areas—are considered to be most vulnerable to the impact of climate change as they have the fewest resources to draw upon in times of crisis. Although considerable improvements have been made (as described in section 3.4.2), the communications infrastructure in many rural areas of Africa is still limited, and rural areas experience generally lower levels of ICT ownership and use (of televisions as well as mobile phones and use of internet). These factors reduce the current potential for ICTs to disseminate information to vulnerable groups, although it is clear that mobile phones and broadcast radio have much greater reach than do alternatives. Even in locations where internet access is available, its quality may be too poor at present to enable effective online collaboration and use of platforms. Sensor networks, meteorological stations and early warning systems are also absent from rural areas of some countries (*e.g*. Malawi).

As governments and donors seek avenues to enhance the potential of ICTs to contribute to adaptation, they will need to pay attention to differences in the reliability and quality of access, and in the coverage and capacity of ICT and complementary systems (such as power networks) within their countries. The potential for ICTs to facilitate adaptation to climate change may be greater for some time in countries where there is high-quality communications infrastructure, such as South Africa and Senegal that enables better access by those living in remote locations.

Related to this is the cost of acquiring and deploying ICT technologies that can support adaptation. At the national level, the establishment and continuous upgrading and use of ICTs to monitor meteorological conditions (*e.g.* weather stations) requires considerable financial outlay. At the individual level, the costs associated with use of mobile phones and internet access can be significant impediments to their use, although these costs are generally falling across the continent.

Existing mechanisms could be used to overcome financing barriers, for example in research and in improving accessibility. Telecom service providers, for example, are required in some countries to contribute a certain percentage of their revenue or turnover to a 'universal service fund' whose intended purpose is to finance access to telecommunications services in remoter areas and by lower-income citizens. The efficacy of these funds has been questioned, and in some cases funds obtained through them have been used for other purposes. The use of universal service funds in this way is open to question, though some have suggested that such models could be used to address both access and cost concerns that limit ICT accessibility by populations particularly vulnerable to climate change.

Capacity to use ICTs remains a constraint in Africa. Lower education levels and a lack of resources for capacity building impede the ability of individuals and organizations to use equipment efficiently. Knowledge of how to operate ICT systems, how to ensure their security from accidental damage and vandalism (including the theft of equipment for resale), and how to use the complex data derived from them remains challenging for people in most rural and many urban communities. There is a shortage of externally-provided content that can be repurposed and made useful for the rural poor[274] (though it should be remembered that the rural poor have also proved highly innovative in findings ways to make ICTs meet their needs, particularly mobile phones). Language presents another level of complexity; many rural Africans do not speak or read the language used by ICT technologies.

Partnerships with technical universities and polytechnics, potentially as part of public-private partnerships, could be established to respond to the capacity gaps that limit the potential for ICTs to be used to enable adaptation. The engagement of these institutions in the development of locally relevant technologies, for instance, could contribute to narrowing the accessibility gap between rural and urban areas. These types of interventions could also contribute to strengthening the capacity of African universities. National Research and Education Networks (NRENs), which are currently emerging, could in future provide infrastructure support and knowledge-sharing beyond the university communities to which they owe their birth.

Finally, **capacity to measure success** with respect to building adaptive capacity and reducing vulnerability to the impacts of climate change remains limited. The international adaptation community

[274] Comment provided by survey respondent, June 2011.

has only recently begun to develop indicators for monitoring the outcomes and evaluating the effectiveness of adaptation projects and programs. It took several years for growth in the ICT sector to produce evidence of economic development—an area in which indicators of success are well recognized. The absence of long term, evidence-based initiatives that identify the specific interventions that have contributed to improving the adaptive capacities of communities to climate change may restrict desired investment in ICTs to support these interventions.

3.5 Opportunities

Although there are challenges associated with using ICTs to support adaptation to climate change, there are also significant opportunities to do so. These result from two factors: the existing use of ICTs in solving problems that are becoming more acute due to climate change; and the rapid growth of mobile telephony and regional infrastructure.

3.5.1 Breadth of adaptation needs

As discussed in Chapter 2, few of the existing adaptation plans and strategies of African countries identify ICT interventions; nor are there a large number of current adaptation-focused projects in which ICTs are explicitly intended or expected to play a central role. However, there is a strong match between the adaptation needs and priority areas of activity identified by African governments and the potential contribution of ICTs. For example:

- Greater knowledge is needed regarding how global climate change is likely to manifest itself at regional, national and local levels. One important mechanism for achieving this is greater investment in meteorological stations, ocean sensor systems, data analysis, and data visualization tools, all of which are ICT-enabled systems.
- The generation, organization and communication of information regarding climate-related risks today and in the future will also make use of ICT resources. This will include the development of early warning and disaster response systems using mobile phone technologies, the development of internet-based learning platform; communication to the public through established media such as radio and television, and the inclusion of climate change knowledge in a formal education system strengthened by the use of ICTs.
- Agriculture is a priority sector for building adaptive capacity in many African countries, with a desire on the part of governments to improve forecasting, establish early warning systems, share experience of climate risk management practices, and provide access to information. ICTs can play an important role in supporting all of these interventions.

- Water is another sector of considerable concern to many African governments. There is a need to monitor surface and groundwater resources, enable flood and drought early warning systems, analyse water quality, understand and visualize data, and communicate with the public – all in ways that could be supported through the use of ICTs.
- Improvement of public health systems is regarded as an important dimension of strengthening the capacity of countries and communities to cope with climate change, and ICTs can also play a role in this domain. For example, they can contribute significantly to monitoring and mapping changing patterns of vector- and water-borne diseases (such as malaria), measuring heat emergences in urban settings, and supporting efforts in disaster management.

These opportunities highlight the need to make governments more aware of the contribution that ICT investments can make in tackling their most pressing adaptation needs, as well as building adaptive capacity in the longer term. They also illustrate that the greater challenge is not about identifying opportunities for the use of ICTs but the prioritization of where ICTs may be used most effectively within the specific climatic and socio-economic contexts of countries, the development goals of their governments and the financial and other resources that are available to them.

3.5.2 Growth of mobile telephony and regional infrastructure

Opportunities also arise because of the growth of mobile telephony and regional infrastructure in the past decade. During this time, access to voice telephony and other basic telecommunications services has become effectively pervasive in Africa due to the spread of mobile networks and private ownership of mobile handsets. Coverage by the end of 2010 approached one subscription for every African adult.[275] Geographical network coverage is not yet complete in Africa, and mobile subscriptions are more common in urban than rural environments for reasons of network availability and relative cost. However, the International Telecommunication Union (ITU) believes that there will be close to 100 percent geographical coverage of African populations by 2015. Increased competition is likely to have driven prices down sufficiently by that time for adult ownership of mobile phone subscriptions to be close to ubiquitous.[276] Mobile networks have now largely eclipsed fixed local access networks, and are expected to be the principal communications medium in Africa in the medium term.[277] The backhaul and backbone infrastructure for these networks is increasingly based around optic fibre rather than wireless technology.

[275] In 2000, there were 88 million mobile telephone subscriptions in sub-Saharan Africa, a density rate of 12.3 subscriptions per 100 inhabitants. By the end of 2010, there were an estimated 333 million subscriptions, a density ratio of 41.4 percent (ITU web page, http://www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom.html).

[276] ITU (2010). *World Telecommunication/ICT Development Report, 2010: Monitoring the WSIS targets: A mid-term review*. Available from: http://www.itu.int/dms_pub/itu-d/opb/ind/D-IND-WTDR-2010-PDF-E.pdf

[277] As in the past, fixed local access is largely confined to major urban centres and the corridors between them, and is used primarily by corporate clients. At the end of 2010, the ITU estimated that there were 13 million fixed lines in sub-Saharan Africa, a density rate of 1.6 percent (ITU web page, http://www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom.html).

This preponderance of mobile networks is also now true of internet access. It has become clear that, in the near and medium term, the principal access medium for the internet in Africa for most individuals will be mobile devices rather than computers. This trend coincides with a change in the nature of the internet, which is becoming more interactive in usage as a result of Web 2.0 applications, particularly social networking. Evidence shows that early adopters in Africa are making heavy use of mobile internet, and it seems at least possible that the pace of mobile internet take-up over the next five to ten years will replicate that of mobile telephony over the past half-decade. Already, over 98 percent of internet subscriptions in Kenya are for mobile internet.[278] This reshaping of internet access from telecentres and cybercafés to mobile phones, and from an elite to a mass market, will have further strong impacts on the potential which these devices have to contribute to building adaptive capacity amongst vulnerable populations.

As mobile phones have become widespread in Africa, attention has moved away from the historic digital divide in access to ICTs towards the digital divide in quality of access, and in particular to the availability of broadband. The importance of broadband to future African development has been emphasised by the World Bank, the ITU and the Broadband Commission for International Development.[279] It is particularly important for sophisticated and multifaceted computing applications, including large-scale interventions concerned with monitoring and responding to climate change. While Africa has been catching up with other world regions in basic communications access over the past five years, the same has not been true of broadband access, where it has failed to match the pace of change taking place elsewhere. At the end of 2010, the ITU estimated that there were only 1 million fixed and 29 million mobile broadband lines in Africa, a density of under 4 percent, compared with a density of some 70 percent (fixed plus mobile) in Europe.[280]

One of the most significant developments in African communications in recent years has been the completion of a number of undersea fibre optic cables along the continent's east coast, where countries had previously been wholly dependent on satellite links for international communications. These competing cables have greatly increased international bandwidth availability and reduced prices for bandwidth and internet access, with significant subsequent impacts on communications use and markets, particularly in the East African Community region. Similar gains in communications access and pricing are anticipated from the introduction of competing undersea cables on the continent's west coast.

[278] Communications Commission of Kenya (2011). *Sector Quarterly Statistics Report*. Available from http://www.cck.go.ke/resc/statistics/SECTOR_STATISTICS_REPORT_Q2_2010-11_x2x_x3x_x2x.pdf.
[279] See *e.g.* Broadband Commission, *The Future Built on Broadband*, at http://www.broadbandcommission.org/#outcomes.
[280] http://www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom.html.

The extent to which these gains are transmitted inland in littoral countries (such as Senegal) or to landlocked countries (such as Uganda and Malawi) depends on the deployment of high-capacity fibre optic backbone infrastructure inland and on competitive interconnection at international border crossings. Many African countries are now seeing rapid development of national backbone networks through private sector investment, public finance (including support from international financial institutions) or a mixture of both. Recent assessments by Hamilton Research suggest that, once all currently planned backbone infrastructure has been deployed, more than three quarters of Africans will live within 50 kilometres of a fibre node, sufficiently close for them to be able to access broadband services through WiMAX where that is available.[281]

The expansion of mobile networks, internet access, and fixed and mobile broadband lines, as well as the completion of undersea fibre optic cables, greatly enhances the potential for ICTs to be used to support climate change adaptation. The expansion of mobile networks and their declining cost is particularly important in enabling ICTs to support adaptation by vulnerable, poor populations. Mobile phones have demonstrated that they can be highly effective as alert mechanisms in countries where they are sufficiently widely available to assure adequate reach within affected populations. They have demonstrated the capacity to deliver information and other services through SMS.[282] The availability of mobile networks also enables human monitoring of changing circumstances through crowdsourcing. This process has the advantage not just of gathering information (to monitor drought risk, for example) but also of engaging local populations in the purpose for which information is being gathered. In addition, it permits remote, unattended monitoring by static devices (such as meteorological stations) which report automatically to control centres and databases. While the scale of information that can be delivered through mobile phones by SMS is limited, the spread of mobile internet and other more sophisticated data services over the next five years will help to overcome this challenge.

Adaptation to climate change can also be supported by more sophisticated and more complex ICTs. Large-scale data analysis, outcome modelling and other computer-led applications are expected to play a significant part in helping national governments, agencies and other stakeholders to adjust their policy and programming to account for the projected impacts of climate change. These potential uses, which are discussed above, should be considered alongside end-user focused outcomes of improvements in telecommunications and internet access. Nor should the value of "old-fashioned" tools and technologies, such as broadcast radio and television, be discounted. These can, in practice, work well both independently and alongside mobile phones in disseminating information. The balance between selection and use of these different media, from a policy and implementation perspective, depends on the desired audience for information and their reach within target communities.

[281] Paul Hamilton, personal correspondence, based on material at http://www.africabandwidthmaps.com/?page_id=27.
[282] For example, in Nepal mobile phones are being used to disseminate information on forestry, natural resource issues, landslides and natural disasters; and in Uganda and Malawi, they are being utilized in conjunction with community radio to relay text messages on climate and environmental questions.

The final point to be made here concerns human capacity. At the heart of adaptation lies the ability of communities to adjust their behaviour to the impacts of changing climatic conditions, including both steps to minimise risk and reduce vulnerability and steps to take advantage of any opportunities that arise. The use of ICTs alone will not achieve this purpose without careful thought being given to their alignment with social norms and practices. Access alone is insufficient to enable ICTs to have an impact on social, economic and environmental outcomes. Achieving these impacts depends on the ways in which people, organisations and institutions interact with ICTs, which in turn depend on the affordability of services and on the human skills which are available to make use of ICT resources, including—in a context like climate change—research and analytical skills. These human factors are critical to determining the potential of ICTs climate change adaptation, and must be included in the analyses of governments and development agencies.

Chapter 4 - Country Case Studies

This chapter reports on three "deep dive" country case studies that were carried out as part of the research for this project. These case studies in Uganda, Senegal and Malawi involved field visits, focus group events, interviews and workshops with stakeholders such as governments departments, civil society organizations, academics and policy makers working in the area of climate change adaptation. It explored how ICTs have been used to help farmers adapt to climate change in Uganda; to address the importance of online knowledge platforms for the sharing of knowledge for adaption in Senegal; and to examine the value of communally generated participatory geographic information systems for water and resource management in Malawi. The research methodology for the case studies is summarised in Appendix 1.

The findings that emerged from these interactions in each country are reviewed in turn below. Each study reviews the ICT tools that are contributing to adaptation within the country concerned. The review team examined governments' and other stakeholders' policy and programmatic response to climate change, focusing on National Communications and strategies, and how ICTs tools relate to them. The final sections of the chapter summarise the findings and draw out common concerns that are applicable to the wider African context.

4.1 Uganda

4.1.1 Introduction

Uganda lies across the Equator in east-central Africa, occupying approximately 241,038 square kilometres, of which open water and swamps constitute a sizable share (43,941 square kilometres, (18.2% of the total area). The country is on average 1,200m above sea level.[283] Lake Victoria, the largest lake on the continent, is located on the country's south-eastern border. Uganda is rich in natural resources, and has relatively fertile soil, rich biodiversity and vegetation, and significant water resources.[284]

[283] Government of Uganda (2007). National Adaptation Program of Action. Accessible here: http://unfccc.int/resource/docs/napa/uga01.pdf

[284] OneWorld Sustainable Investments (2008). Inception Report: Climate Change Vulnerability Assessment, Adaptation Strategy and Action Plan for the Water Resources Sector in Uganda. Accessible here: http://www.oneworldgroup.co.za/projects/climate-change/service-one/

Uganda has one of the highest population growth rates in the world, with its current population of 33 million[285] expected to double by 2035.[286] The large majority of the population resides in rural areas. Although its Human Development Index and income poverty have improved considerably in the last decade, it remains one of the poorest countries in the world, particularly in rural areas.[287]

Uganda's GDP grew at a little over 5 percent during the first decade of the century, and was not badly affected by the global economic downturn.[288] The economy is dependent on agriculture. Approximately 80 percent of the population derives its livelihoods from this sector, including subsistence farming, and agriculture generates 90 percent of export earnings.[289] Addressing challenges in the agricultural sector is therefore a major priority for the country. Uganda is one of the leaders in implementing the Maputo Declaration on the Comprehensive Africa Agriculture Development Programme (CAADP) in which the government committed the country[290] to the principle of agriculture-led growth as a main strategy, aiming to achieve 6 percent average annual growth rate for the sector and to increase the share of the national budget allocated to it towards an eventual target of 10 percent.

Uganda's ICT landscape is vibrant, with a mobile teledensity rate of 32.8 percent in 2009 and a mobile geographic coverage of well over 70 percent of its population (see Box 4-1).

[285] http://www.state.gov/r/pa/ei/bgn/2963.htm
[286] IFS (2011) Population projection for the Global Environmental Outlook – UNEP. University of Denver, Denver.
[287] UNDP (2007). Uganda Human Development Report 2007. Accessible here:
http://planipolis.iiep.unesco.org/upload/Uganda/Uganda_National_Human_Development_Report_2007.pdf
[288] http://www.indexmundi.com/g/g.aspx?c=ug&v=66
[289] OneWorld Sustainable Investments (2008). Inception Report: Climate Change Vulnerability Assessment, Adaptation Strategy and Action Plan for the Water Resources Sector in Uganda. Accessible here:
http://www.oneworldgroup.co.za/projects/climate-change/service-one/
[290] National Development Plan (2010). National Development Plan 2011 – 2015, Government of Uganda, Kampala.

Box 4-1: Uganda's ICT context

Uganda was one of the first countries in Africa to restructure its telecommunications market through the linked processes of liberalization, privatization and regulation which have become standard throughout the continent (and the world). Uganda's sector restructuring, which began in the 1990s, was also unusual in that the second national operator licence in the country was awarded to a company whose business plan was based on wireless rather than fixed technology. This can be seen as an early example of the technology-neutral approach to telecoms restructuring which has become fashionable within the last few years and is now considered appropriate for convergent telecommunications and broadcasting industries.

Uganda today has a highly competitive telecoms market, in which the overwhelming majority of access is derived from mobile subscriptions. Licences are issued for infrastructure provision and service provision, with a total of 24 infrastructure and 35 service licences issued by 2009, although not all of these are active. In 2007, the number of infrastructure-based mobile operators rose from three to five, and two further licences have subsequently been issued, raising the level of competition well above that in most African countries (and perhaps beyond sustainability).[291] In October 2009, MTN was the main service provider with 41% market share, followed by Zain (22%), the former incumbent UTL (19%), Warid (17%) and Orange (2%).[292] After Airtel acquired Zain's African businesses in 2010, it claimed that its market share had risen to 35%.[293]

All of these companies may use fixed or wireless infrastructure to provide services, although in practice fixed services are provided primarily by the former incumbent UTL and by MTN. The large number of market players, the acquisition of Zain by Airtel and aggressive price competition by Warid has led to price reductions over the past eighteen months or so. Current price levels have been described as unsustainable by some operators, particularly for off-net prices. The regulator (UCC) has sought to achieve further reductions in prices by addressing interconnection rates.

In spite of the level of competition, teledensity in Uganda is still relatively low. As of 2009, the mobile teledensity rate was 32.8%, and the rate of growth in 2009-2010 was lower than it had been the previous year.[294] Pyramid Research attributes this relatively low rate to the lack of affordable last-mile access to rural areas, where the majority of Ugandans live and where income levels are too low to justify individual subscriptions and handset ownership for many potential customers. Although the country's population is predominantly rural, 70% of mobile connections are in urban areas. Because the country is relatively small and densely populated, the geographical coverage of mobile signals is largely complete, although this is less true of the area subject to Lord's Resistance Army insurgency in the north of the country than it is elsewhere. A systematic application of mobile environmental monitoring applications could benefit from this wide geographic coverage.

Two additional factors should be borne in mind when considering the spread of communications in the country.

Firstly, Uganda has had a significantly more positive experience of universal access funding than most African countries. Its Rural Communications Development Fund (RCDF), which is principally financed from a 1 per cent levy on telecoms company revenue, has been much more active in disbursing funds than others on the continent (many of which are criticised for failing to make proper use of funds). As well as payphones, disbursement has included internet points of presence, facilities in schools and clinics and other public locations This may have extended the range of information channels available for communicating climate change adaptation content or for

[291] See UCC website at www.ucc.go.ke.
[292] http://www.cellular-news.com/story/40039.php.
[293] http://allafrica.com/stories/201102160211.html.
[294] http://www.itu.int/ITU-D/ict/newslog/Ugandas+Broadband+Revenues+To+Surge+With+Arrival+Of+New+Cable+Capacity.aspx.

deploying sensor networks for the generation of climate information and data. The impact of Uganda's RCDF has not been evaluated, but it is generally regarded as more successful than most universal access programmes in Africa.[295]

Secondly, Uganda has a very high level of taxation of communications usage, amounting to around 30% of usage charges, making mobile telephony the largest single source of government tax revenue. Taxing mobile telephony is highly attractive to African governments because a large amount of tax can be collected from a small number of companies, because the tax is difficult to avoid, and because the amount of revenue obtained from it is growing as use of phones increases. Operating companies, however, argue that it is a constraint on the adoption and use of mobile phones by the poor.[296]

The most important new feature in the Ugandan communications landscape in recent years has been the advent of several competing undersea fibre cables along the east coast of Africa, followed by the construction of new cross-border links between landlocked Uganda and Kenya (enabling connection to cable landing points) and of national broadband backbone infrastructure financed by both government and private sector money. Investment in Ugandan telecoms rose substantially in 2007 and has continued since at levels higher than had been the case in the run-up to that date, including through the recent economic downturn. These infrastructure improvements are bringing much higher internet capacity to Uganda (available international bandwidth is said to have quintupled), with reductions in internet prices (although these have taken some time to emerge). With changes in handset technology, this is expected to drive growth in mobile data which could exceed 20% per annum over the period to 2015. [297]

Uganda's ICT policy is led by a (relatively recently) converged IT ministry, and a converged regulatory agency has now been established. However, the government's current ICT policy document dates from 2003, well before current market circumstances emerged, and so provides a very poor guide to current issues.[298] A substantial stakeholder consultation exercise was undertaken to revise the policy in 2005, but this has not yet resulted in a new policy document - although the outcome of discussions during the consultation has had an impact on policy and regulatory decisions. A government position paper on a national broadband strategy in 2009 recommended that Uganda should position itself as a regional communications hub, though national aspirations in this regard potentially conflict with similar aspirations in Kenya and Rwanda. Some of the implementation choices made in respect of this strategy, which initially concentrated on improving government facilities, have been controversial.

In sum, the geographic coverage of mobile signals presents an opportunity for the deployment of more intelligent environmental monitoring devices, including sensor networks, and user-generated climate data that could be transmitted over this network. The current state of ICT policy development likewise offers an opportunity to synchronize the deployment of ICTs with existing climate change related development plans and strategies. A new ICT policy could benefit from the inclusion of strategies that specifically address climate change.

[295] http://www.ucc.co.ug/rcdf/index.php.
[296] GSM Association, *Taxation and the Growth of Mobile in Sub-Saharan Africa*, http://www.gsmworld.com/our-work/public-policy/regulatory-affairs/taxation_and_growth_of_mobile_sub-saharan_africa.htm.
[297] http://www.budde.com.au/Research/Uganda-Telecoms-Mobile-Broadband-and-Forecasts.html.
[298] http://www.ucc.co.ug/nationalIctPolicyFramework.doc.

4.1.2 Uganda's climate change context

Research and analysis of data have shown evidence that climate change is having an impact on Uganda. Average annual temperature has increased by 1.3°C since 1960, with a significant rise in the number of hot days and nights.[299] Statistically significant declines have been observed in rainfall since the 1960s, decreasing by 3.5 percent per decade along with an increasing frequency of drought.[300] Analysis of data from 1900-2000 shows significant drought episodes increasing from every 20 to 16 years down to 5 years.[301] More frequent extreme weather events including droughts, floods and consequential landslides have been frequent over the past several decades[302] and dramatic reductions have been observed in the snow cover in the Ruwenzori range.[303] Rapid spread of banana bacterial wilt disease has occurred, probably associated with temperature increases. Coffee mealy bugs have reappeared, most likely for the same reason. Both of these threaten agricultural livelihoods.[304] Lower water levels in the country's lakes have exposed fish breeding grounds which affect the numbers of fish for subsequent seasons.[305] There has been speculation that Lake Victoria's drop in water levels from 2000-2006 may be due to climate change, although this is difficult to judge because of excess releases at the outflow of the lake for power generation purposes.[306]

In the face of these difficulties, Uganda has made much positive progress in climate change adaptation efforts over the past several years. The issue has gained political salience within the country, mainly through the activities of, donors and funding agencies.[307] Recent efforts have led to the creation of a Climate Change Unit within the Ministry of Water and Environment, a Parliamentary Forum on Climate Change, and to efforts to integrate climate change within the National Development Plan and in the sectoral plans for water and agriculture.[308]

[299] McSweeney, C *et al* (2009). UNDP Climate Change Country Profiles: Uganda. Accessible here: http://country-profiles.geog.ox.ac.uk/index.html?country=Uganda&d1=Reports

[300] McSweeney, C *et al* (2009). UNDP Climate Change Country Profiles: Uganda. Accessible here: http://country-profiles.geog.ox.ac.uk/index.html?country=Uganda&d1=Reports

[301] DSIP, (2010). *Ibid*

[302] Government of Uganda (2007). National Adaptation Program of Action. Accessible here: http://unfccc.int/resource/docs/napa/uga01.pdf; OneWorld Sustainable Investments (2008). Inception Report: Climate Change Vulnerability Assessment, Adaptation Strategy and Action Plan for the Water Resources Sector in Uganda. Accessible here: http://www.oneworldgroup.co.za/projects/climate-change/service-one/

[303] DSIP, (2010). *Ibid*

[304] DSIP, (2010). *Ibid*

[305] DSIP, (2010). *Ibid*

[306] DFID (2008). Climate Change in Uganda: Understanding the implications and appraising the response. Prepared by LTS International for DFID. Accessible here: http://www.reliefweb.int/rw/RWFiles2008.nsf/FilesByRWDocUnidFilename/SNAA-7PT6WK-full_report.pdf/$File/full_report.pdf

[307] (Hepworth, 2010)

[308] Hepworth, (2010)

4.1.3 Impacts of climate change on the agriculture sector

Major potential impacts of climate change on the agricultural sector have been identified in recent studies. A preliminary Vulnerability and Adaptation to Climate Change study was carried out to guide the development of the country's NAPA. This covered the agriculture (crop and livestock), water resources and forestry sectors. Three General Circulation Models (GCMs) were used and all of these predicted an increase in temperature of between 2 and 4°C, variations in rainfall with an increase of 10 to 20 percent over most of the country but a decrease in its semi-arid cattle corridor; a 10 to 20 percent increase in run-off for most of the country, and an increase in the frequency and severity of flooding, droughts, soil erosion and siltation.[309] [310] [311] These factors were discussed during the country visit, at national workshops and at interviews with stakeholders including farming communities, civil society organizations and government agencies.

A National Participatory Scenario Development Workshop was held during 2011 as part of the Climate Risk Management Technical Assistance Support Project (CRM TASP). This was organized by the UNDP country office in Uganda and the International Institute for Sustainable Development (IISD), and funded by the UNDP Bureau for Crisis Prevention and Recovery (BCPR).[312] Agreement was reached to incorporate into the workshop an exploration of the role that ICTs can play in adapting to climate change. This component was supported by the eTransform Africa project.

During the workshop, forty representatives from different ministries at national and district levels, civil society organizations, academia, the private sector and donor agencies identified and prioritized climate risks and risk management options up to the year 2035 for maize, beans and coffee production for two districts of Uganda, based on the results of a climate risk assessment.[313] The climate risk assessment had been conducted as part of the CRM TASP, and derived information from a literature review, consultations at community and district levels using the Climate Vulnerability and Capacity Analysis (CVCA) and CRiSTAL tools, crop modelling for maize and beans using the Decision Support System for Agrotechnology transfer (DSSAT) model, and a series of interviews with coffee stakeholders at national

[309] Government of Uganda (2007). National Adaptation Program of Action. Accessible here: http://unfccc.int/resource/docs/napa/uga01.pdf

[310] McSweeney, C *et al* (2009). UNDP Climate Change Country Profiles: Uganda. Accessible here: http://country-profiles.geog.ox.ac.uk/index.html?country=Uganda&d1=Reports

[311] DFID (2008). Climate Change in Uganda: Understanding the implications and appraising the response. Prepared by LTS International for DFID. Accessible here: http://www.reliefweb.int/rw/RWFiles2008.nsf/FilesByRWDocUnidFilename/SNAA-7PT6WK-full_report.pdf/$File/full_report.pdf

[312] Held in Entebbe in July 2011

[313] Brief Report Excerpt provided by Julie Karami, IISD.

and district levels.[314] Outcomes that were validated and which further grounded the climatic predictions described in the previous section showed that:

- Floods and droughts have had major impacts on crop production and people's livelihoods, as farmers have struggled to cope with the negative impacts of these hazards.
- The impact of climate change on production of maize and beans in both districts should be minimal and can be more than offset with better irrigation. However, the model used does not account for indirect impacts of climate change (such as diseases, pests and erosion).
- Both Robusta and Arabica coffee, the two varieties grown in Uganda, are vulnerable to climate hazards which have contributed to the decline in coffee production in Uganda since 2000.

The workshop programme comprised five main sessions, which were concerned with:

1. major trends and vulnerability in the agricultural sector and in crop production at national and district levels;
2. impacts of climate variability and climate change on crop production and future risks in Rakai and Kapchorwa districts;
3. existing capacities and responses to climate risks at national and local levels;
4. the role of ICTs in climate risk management; and
5. conclusions and recommendations.

Stakeholders concluded that:

- Much knowledge on climate risk is available at all levels, but this knowledge is not shared adequately.
- There is a need to foster synergies and coordination between government ministries and to prioritize the role of ICT tools to support climate risk management.
- Various national development plans, policies and strategies related to crop production have already been developed and most have mainstreamed climate risks.
- There is a need to operationalize policies so as to translate climate risk mainstreaming into concrete actions.
- It is important to consider how other threats (such as HIV/AIDS) interact with climate risks.

A visit was also made as part of the research for this study to farmers in two districts of Kacheera subcounty in Rakai District and Kawowo sub-county in Kapchorwa district. The aim of this visit was to

[314] Community Vulnerability and Capacity Adaptation (CVCA) framework; Community Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL); Decision Support System for Agrotechnology Transfer (DSSAT)

understand local responses to the impacts of climate risk on maize, beans and coffee production. The following observations resulted from this visit:

- The correlation between climate variability and coffee diseases needs to be further researched and findings published. Most risk management strategies for coffee production are still at the pilot stage. They need to be evaluated and scaled up where appropriate.
- An information drought has resulted following the loss of government intermediaries (support and extension workers) who previously provided climate change related knowledge and weather information. This has probably resulted from a lack of funding support (see 2: Seasonal Climate Forecast and Agricultural Producers). Other mechanisms for sharing information such as radios, telephones and community notice boards have not always been useful to farmers in the area, most of whom are illiterate. This has resulted in poor coordination and harmonization of community projects, and in dependence by farmers on windfalls from these initiatives rather than carefully constructed support that engage them in managing their own development.
- Community facilitators and go-betweens, such as Community Knowledge Workers (See Box 4-2) are needed to bridge the gap between largely illiterate farmers and local government information services. Strategies should acknowledge and develop existing knowledge, combining scientific and indigenous knowledge and enhancing local capacity by working with local institutions and councils.

Box 4-2: Seasonal Climate Forecast and Agricultural Producers

The Department of Meteorology, which reports to the Ugandan Ministry of Water and Environment, provides three-month seasonal weather forecasts, with brief interpretation to help farmers understand the forecasts' implications for crop production and livestock. These forecasts focus on temperature and precipitation and cover all regions of the country (Eastern, Central Northern, Western, and Lake Victoria Basin and Central areas). [315] Impact advisories for the forecasts are generated using inputs from a number of sources – the 27th Climate Outlook Forum held on February 28, 2011 in Arusha, Tanzania; a review of global climate systems and their implications for seasonal climate; and the influence of sea surface temperature anomalies over the tropical Pacific, Atlantic and Indian oceans on the evolution of rainfall in the Greater Horn of Africa Region.

The forecasts provide two broad types of data - weather and climate information, and advisory guidance to communities and farmers. The advisories warn farmers to adopt appropriate farming practices and approaches to land use management, to manage stock with a view to potential drought and pest attacks, to harvest water for home and irrigation, and to seek advice from extension workers on adaptive farming practices.

Although these messages are disseminated using SMS and the Meteorological department's website, the effectiveness of this information can be questioned. While many farmers can access SMS, few have regular access to the internet. Even SMS dissemination is problematic. The cost of sending a message is the same as with regular SMS. Illiteracy is widespread and the service is provided in English rather than indigenous languages. There is a shortage of community workers to bridge gaps in information dissemination. In practice, most farmers who were asked during the National Participatory Scenario Development Workshop as part of the Climate Risk Management Technical Assistance Support Project (CRM TASP) were not aware that this service exists. The lack of a mechanism for feedback has made it difficult for the department to judge the efficacy of its service.

There are opportunities for improve the application of existing technologies in order to produce better outcomes. For example, an intermediary translation web or mobile service to automate data translation into local languages such as the Distance Early Warning System for Tsunamis, described in Chapter 3, could help in reducing language barriers. A voice activated service providing local knowledge could also help, especially if it were free of charge. Whatever else is done, however, it would be useful to enhance the ability of the Department to provide information on longer term climatic risks. The present system provides information, advice and warnings concerned with short term risks and adaptation actions. More technical capacity and infrastructure are required for long term climate projections and to support improved domestic resilience strategies and planning.

Stakeholders in the project workshop recognized the opportunities that ICTs could play in improving outcomes, particularly in sharing knowledge, building networks, facilitating better coordination (see Box 4-4: Cassava yield monitoring project and farmers network), storing and maintaining indigenous knowledge, and raising awareness of factors that could negatively influence risk management. One important observation was that local development initiatives – including the outcomes of local research and pilot implementation – need to be better documented and shared among and between stakeholders.

[315] http://www.meteo-uganda.net/marmay2011.doc, accessed September 2011

The cases described in Boxes 4-2, 4-3 and 4-4 contribute to building the response capacity and to addressing the drivers of vulnerability in the local communities in which they have been implemented. This is consistent with the framework presented in Chapter 1.

Box 4-3: Community Knowledge Workers

In 2002, working with the telephone company MTN Uganda, the Grameen Foundation[316] replicated in Uganda its implementation of a Village Phone service in Bangladesh. The Village Phone concept was of a microcredit enterprise that allowed women to acquire ownership of a phone kit which they could operate as a village call centre. As well as basic telephony, this service could provide instant information on business, agriculture, health, environment and weather to rural communities in Uganda.[317] To receive information, farmers sent key words by SMS to a short code which returned relevant answers from a database. For instance, "Weather Masaka" or "Embeera Masaka" (local language query) returns weather information in Masaka. "Banana Wilt" returns relevant information about that disease. (See inset box for a sample message.)

Sample Database Message

'To protect stored seeds from weevils, get sacks and fill them with grains up to 75% and roll /turn them daily during the first week after harvest. This reduces the infestation by weevils up to 98%.'

'Aphids are very dangerous to beans. To control them, get one Jeri can of cow urine, add one bundle of coach grass, add it to the Jeri can and keep for two months. Remove and measure 5 cups of the solution, add 20 cups of water and spray on the beans.'

Source: www.applab.org

The database for this service is populated with data provided daily by the Ugandan Department of Meteorology, while locally relevant agricultural information is provided by a local organization called the Busoga Rural Open Source Department Initiative. Health and trade information are provided by local organizations with expertise and knowledge in those respective fields. All information is reviewed by experts from regional and international organizations to ensure its accuracy before propagation. This poses a significant management burden which it would be difficult to replicate across a large number of local services).However, it defines a collaborative structure that if better refined could result in a much more efficient concept of knowledge and information management.

The Community Knowledge Workers (CKW) – a network of locally-based "trusted intermediaries" who interface between content producers and smallholder farmer groups – was added in 2008 to: a) conduct mobile based surveys of their communities which are then uploaded to a central server and b) act as the conduit for dissemination of centralized information to community farmers.[318] The objectives of the CKW include improvements in farm productivity, increases in revenue and the collection of information that can help farmers to meet their needs.[319] Specific types of information that the CKWs transmit which are relevant to climate change adaptation include:

- advice on land preparation based on available weather forecasts, especially expected rainfall;
- information on pests (farmers can send pictures of an infested crop and seek diagnostic advice);
- information about value-chains, market prices and opportunities; and
- Information about available storage facilities.

CKWs are themselves farmers and are elected by fellow members of local cooperative farmer groups. They must

[316] http://www.grameenfoundation.org/sub-saharan-africa/uganda
[317] http://mtn.co.ug/About-MTN/News-Room/2009/June/MTN-partners-with-Google-and-G.aspx
[318] http://www.grameenfoundation.org/what-we-do/empowering-poor
[319] http://www.grameenfoundation.org/sub-saharan-africa/uganda

speak English, must be judged innovative in their farming practices, must be willing to serve their communities, and must aspire to meet target objectives which are regularly checked and monitored through an online dashboard. They are incentivized with a rented smartphone kit which is preloaded with applications concerned with crop production such as land preparation and weather projections; a solar or bicycle operated battery recharge system to power community cell phones; and a shirt, hat and vest to indicate their role. Research which they conduct includes household surveys, GPS location data and farmer registration information.

As of July 2011, over 20,000 farmers and households have been registered by a total of 463 CKWs. The initiative aimed to achieve a total of 800 CKWs by the end of 2011.

Application Laboratory (AppLab)[320] is responsible for the development of the mobile applications that allow access to data on health and agriculture. Services are extended to researchers, research institutions and organizations that are seeking local-level grassroots data. New surveys for community-based data requested by external research interests are deployed through CKWs and the data collated at the dashboard are transmitted over mobile networks. All applications have the capability to store and forward data in instances of dropped connectivity, guaranteeing data integrity, though better means of managing data may be required. Sustainability is assured if research interests can pay for data generation. One challenge to sustainability, however, is the cost of SMS.

Based on a recently conducted review of the CKWs and AppLab programs, 75 percent of farmers reported that they found the information they received very useful; 30 percent of farmers said that they went to a better market as a result of information received; 30 percent said that they were able to negotiate better pricing deals, and 30 percent said that they had changed their practices and planted different crops because of weather forecasts accessed through the project.[321]

4.1.4 Policy response to climate change

The government of Uganda, like those of many LDCs, has agreed national response documents to address the impacts of climate change. Its strategies for identifying adaptation needs, priorities, and planned actions include, among others, the National Adaptation Programme of Action (NAPA); a National Communication under the UNFCCC; the 5-year National Development Plan (NDP); and the Agriculture Sector Development Strategy and Investment Plan (DSIP).[322] All of these strategies recognize the significance of climate change impacts on agricultural production. For instance, the NAPA, which was developed in 2007, recognized land and land use, forestry, water resources and health as policy domains that were particularly vulnerable to climate change on which adaptation investments should be focused; and identified weather and climate information, awareness-raising, policy, legislation and infrastructure, as areas of activity for such investment. [323]

[320] www.applab.org
[321] Discussions with CKW/Grameen Foundation Project Manager, Held July 2011
[322] IISD (2011), *Adaptation Review of Current and Planned Adaptation Action: Middle Africa*, first draft (April 2011), unpublished report.
[323] Government of Uganda (2007). National Adaptation Program of Action. Accessible here: http://unfccc.int/resource/docs/napa/uga01.pdf

Uganda's National Communication to the UNFCCC provides an inventory of GHG mitigation options, reviews national policies and measures, and sets out options to deal with the impacts of climate change, particularly noting the importance of education and public awareness. New plans and strategies are focused on long-term development – a shift away from the focus on poverty reduction in development planning over the last twenty years. For instance, the NDP (2011-2015) marks a broadening of the existing development strategy towards structural transformation for growth and increased living standards, away from the poverty focus in the previous Poverty Eradication Action Plan (PEAP).[324] The DSIP, adopted in 2010 for the period 2011–2015,[325] seeks to create a competitive, profitable and sustainable agricultural sector by linking agricultural development and improvements in people's livelihoods through increased rural incomes, and through improved household food and nutrition security. Uganda's livelihoods and food security are particularly vulnerable to the effects of climate change, given the high proportion of the population that depends on rain-fed agriculture.[326]

[324] http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/UGANDAEXTN/0,,menuPK:374947~pagePK:141132~piPK:141107~theSitePK:374864,00.html

[325] DSIP (2010). *Agriculture for Food and Income Security* Agriculture Sector Development Strategy and Investment Plan: 2010/11- 2014-15. Ministry of Agriculture, Animal Industry & Fisheries, Kampala, pp. 149

[326] Government of Uganda (2007). National Adaptation Program of Action. Accessible here: http://unfccc.int/resource/docs/napa/uga01.pdf

Box 4-4: Cassava yield monitoring project and farmers network

Cassava is a popular food security crop among small-scale farmers in Uganda and in the Great Lakes region because of its flexible harvest period and long ground storage, its ability to tolerate both poor soil and its drought-resistance. It is both a food and cash crop in many farming communities, especially in the central, eastern and northern regions.[327] The Food and Agricultural Organization (FAO), with funding from the European Union, has initiated a regional Cassava Initiative in support of vulnerable householders in Central and Eastern Africa, to address the continuing spread of Cassava Mosaic Disease and Cassava Brown Streak Disease. It is distributing cassava varieties which are tolerant of and/or resistant to these diseases to vulnerable small-scale farmer communities which have been resettled following displacement as a result of armed conflict.

The FAO has also developed a tool that enables the collection of information on expected cassava yield. Mobile phones are used to collect information about the size, health and expected yields of the crops that have been planted. The tool monitors expected yield from the early stages of planting, and then generates projections for the total harvest and potential food shortages based on a number of parameters. It does not provide climate projections but does provide information on short-term risks that can enable farmers to respond to current climate-related crises. This information can help farmers to prepare for food shortages and insecurity and thereby reduce their vulnerability. The efficiency of the tool depends on a supporting network of farmers and farmers' organizations that are willing to provide the required information.

As a mapping tool, this could be adapted to different crops, different network of farmers and different countries. However, the success of this tool in other contexts will depend on the presence of farming networks that are willing to provide the sort of information necessary for the methodology, and on the suitability of different crops for this kind of predictive analysis.

4.1.5 Programmatic approaches and opportunities for ICTs

The government of Uganda has identified a number of priority adaptation projects in its NAPA to address drought, halt and reverse land degradation, improve water utilization, and strengthen and control capacity for the prevention and management of disease.[328] In addition, agriculture-related projects acknowledge that there are gaps in knowledge and information management which present opportunities for the use of ICTs. For instance, ICTs are able to improve data collection and the availability, accuracy and timeliness of weather and climate information to people accessing new services. ICTs can be used to reduce gaps in technical knowledge and capabilities, and in the maintenance, protection and continued use of indigenous knowledge for the management of natural resources. Another project in Uganda seeks to mainstream adaptation into existing development

[327] http://www.fao.org/fileadmin/templates/tc/tce/pdf/FAO_UGANDA_Information_Bulletin_May_2010.pdf, accessed September 2011

[328] Government of Uganda (2007). National Adaptation Program of Action. Accessible here: http://unfccc.int/resource/docs/napa/uga01.pdf

initiatives by improving the collection and dissemination of climate information through the internet and radio.

These different initiatives, all identified in Uganda's NAPA, recognize the importance of ICTs. Little has been done, however, to explore their potential more comprehensively – particularly in developing local research and technical capacity or knowledge and information-sharing. The capacity to document local climate change initiatives, to produce knowledge on how communities are adapting to climate change, and even more broadly, the capacity for rigorous and systematic academic research in the climate change arena, are still largely missing. Reports prepared in the past few years that survey adaptation action suggest the need for research and knowledge creation for climate change as well as project coordination. One study for GIZ investigated the different actors involved in climate change adaptation and mitigation efforts in Uganda. This identified some 84 different governmental and NGO actors in the country.[329] Such large numbers of actors involved in projects that are seldom documented will almost certainly lead to duplication of activities. There is a strong case for greater coordination, better communication and more networking among stakeholders and for greater synergies to be realized between projects.[330] ICTs can facilitate such coordination.

4.1.7 Summary

The summary findings of this case study of Uganda are, therefore, that:

- Uganda is a country largely dependent on its agriculture, which generates over 90 percent of its export earnings and which could be strongly impacted by climate change.
- Research is required in a number of areas, particularly those concerned with the relationship between climate variability and diseases in coffee and other crops. Gaps in the research landscape need to be filled by supporting the development of local research and technical capacity for knowledge- and information-sharing, including information about existing practices.
- Human interface or community knowledge workers, armed with appropriate ICTs, are needed to improve coordination, foster synergies, raise awareness, share knowledge and build local capacity, and to bridge the communication gap between communities of farmers and national meteorological offices, government offices, research, financial institutions and other stakeholders.
- ICTs can be applied to strengthen existing meteorological services in the areas of data collection, and of the availability, accuracy, and timeliness of data distribution. Weather and climate related information is often out of date by the time it reaches its target audience. ICTs could

[329] Preller, (2009)
[330] Preller (2009)

assist in disseminating information more quickly, in improving its local relevance and translating it into local languages, in maintaining and preserving successful adaptation practices, and in fostering convergence between indigenous adaptation techniques and new scientific knowledge.

4.2 Senegal

4.2.1 Introduction

Senegal is located on the West Coast of Africa and is a member of the Economic Community of West African States (ECOWAS) and the West African Economic and Monetary Union (UEMOA). With a population of about 12.5 million, its economy is dominated by a few strategic sectors, including groundnuts, fisheries and services.[331] Senegal has one wet season between July and September. Temperatures generally rise from the coast towards the east in most seasons, except during the wet season, when the cooling influence of cloud and rainfall results in a cooler south than north.[332]

Senegal is highly dependent on exploitation of its natural resources, many of which are being depleted by unsustainable livelihood activities. The informal sector accounts for about 60 percent of gross domestic product (GDP).[333] Agriculture, fishing and tourism help to maintain livelihoods by creating jobs and generating income.[334] Senegal's dependence on natural resources is susceptible to climate change, which consequently impacts on its economic growth and development objectives.[335]

High levels of rural poverty and limited access to rural infrastructure and basic services have fuelled migration to urban areas. Poor people in rural areas, women, the elderly, farmers, fishermen, market gardeners and those who depend on tourism are considered most vulnerable to the effects of future climate change.

Senegal's ICT landscape has seen considerable growth in recent years with telecommunication contributing about 6 percent of its GDP. Mobile and telephone networks are geographically widespread and the cost of access to the internet is falling. Box 4-5 describes the country' ICT environment.

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[331] http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/SENEGALEXTN/0,,menuPK:296312~pagePK:141132~piPK:141107~theSitePK:296303,00.html

[332] McSweeney, C *et al* (2009). UNDP Climate Change Country Profiles: Senegal.

[333] http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/SENEGALEXTN/0,,menuPK:296312~pagePK:141132~piPK:141107~theSitePK:296303,00.html; Ministry of the Environment and Nature Protection (Ministère de l'Environnement et de la Protection de la Nature) [MEPN] (2006). Plan d'action national pour l'adaptation aux changements climatiques (NAPA). Dakar : MEPN.

[334] Ibid.

[335] Ministry of the Environment and Nature Protection (Ministère de l'environnement et de la protection de la nature) [MEPN] (2010). Deuxième communication nationale du Sénégal. Dakar: MEPN.

Box 4-5: Senegal's ICT context

Senegal is generally regarded as having a more advanced telecommunications environment than most countries in Francophone West Africa. It has a substantially higher telephone subscription rate than most African countries, estimated at 68.5 lines per 100 inhabitants in 2011 (8.34 million lines).[336] Mobile phones are expected to approach adult ubiquity within the next five years.

Of the three operating companies, one – Orange Senegal (the former incumbent Sonatel) – was significantly dominant in early 2011, with around 60% market share, compared with a little under 30% for Tigo and just over 10% for Sudatel (which entered the market in 2009 and holds the second national fixed licence as well as operating a mobile service). The incumbent Sonatel, according to one market analyst, "has one of the most efficient telecoms markets in West Africa, offering some of the lowest retail and wholesale prices in the region, although they are still high by global standards."[337] A fourth mobile licence has been awarded and will provide service from late 2012, bringing the level of competition in Senegal up to that found in many other countries.

Developments in international submarine cable capacity are expected to have a big impact on internet access and pricing. The landing of a second submarine cable in 2007 greatly increased the capacity available to the country, and two further submarine cables should become available by the end of 2012. As a coastal country, Senegal is not hampered by the need to secure cross-border interconnection to access global networks, though countries such as Mali (which is landlocked) look to it for access to a coastal landing station. The advent of new cables should bring to an end the constraint on internet access caused by the high pricing of capacity on the SAT3 cable which has been widely criticised in recent years. Although broadband prices continue to fall, the cost of access to broadband TV and converged triple play services continues to rise.[338]

ICTs have been given prominence in national development policy in Senegal, with strong support at presidential level and a direct link between the presidency and decision-making agencies. There has been criticism of the degree of transparency in past licence awards, but this does not seem to have affected the sector's growth adversely: it now represents about 6% of GDP, and grew significantly through the downturn, seeing substantial investments by licenced operators and the introduction of new service offerings such as mobile money.
The regulatory environment – managed by the regulator ARTP - received a mixed report from industry stakeholders in a recent study by Research ICT Africa.[339] This found that most stakeholders felt that, while the mobile sector was generally progressing well, there was insufficient entry in the fixed market and a need for more effective price regulation across the board.

In summary, the telecoms market in Senegal is pervasive which implies that mobile devices can be used with confidence for mass information dissemination, including rural areas. The quality of backbone infrastructure is also high, across the country as a whole, implying that high-bandwidth applications can be deployed nationwide with confidence.

[336] http://www.itu.int/ITU-D/ict/newslog/Senegal+Mobile+Base+Tops+834m+At+End2010.aspx.
[337] http://www.budde.com.au/Research/Senegal-Telecoms-Mobile-Broadband-and-Forecasts.html.
[338] *ibid.*
[339] http://www.researchictafrica.net/publications/ICT_Sector_Performance_Reviews_2010/Vol_2_Paper_20_-_Senegal_ICT_Sector_Performance_Review_2010.pdf.

4.2.2 Senegal's climate change context

Senegal's[340] mean annual temperature has increased by 0.9°C since 1960, an average rise of 0.2°C per decade. Available data indicate that the average number of 'hot' nights per year increased by 27 percent (an additional 7.3 percent of nights) between 1960 and 2003. Sahelian rainfall is characterised by high variability on inter-annual and inter-decadal timescales, which can make long-term trends difficult to identify. Statistically significant decreases of around 10 to 15mm per decade have, however, been observed in the southern regions of Senegal in the wet season between 1960 and 2006. Some unusually high rainfalls have occurred in the dry season in recent years (2000-2006), but this does not seem to represent a consistent trend.

Projections of future climate trends in Senegal are restricted by lack of information. Insufficient daily temperature observations are available from which to identify trends in temperature extremes with a high degree of confidence.[341] Based on the information that is available, models project a mean annual temperature increase of 1.1 to 3.1°C by the 2060s, and 1.7 to 4.9°C by the 2090s. The rate of warming is expected to be more rapid in the interior of the country than closer to the coast. Projections of mean annual rainfall suggest a wide range of changes in precipitation around the country, but with a general decrease in the wet season. Projected annual change ranges from -38 percent to +21 percent by the 2090s. Despite projected changes in total rainfall, the proportion of total annual rainfall during heavy events tends to increase.[342]

The rise in sea level along Senegal's coastline is a cause of concern because of ongoing erosion which results from the coastal zone being part of a regional sediment transportation corridor.[343] Fresh water supply has been reduced as a result of this, of changes in the rainfall pattern, and because of saline intrusion.[344] Between 55 and 86 kilometers of beach will disappear by 2100 along the coast if sea level rises by one meter and if coastal erosion continues to intensify.[345] Concurrently, some 6,000 square kilometres of low areas, notably the estuaries would be flooded.[346]

4.2.3 Policy and practical responses to climate change

[340] IISD, *Adaptation Review of Current and Planned Adaptation Action: West Africa*, first draft (April 2011), unpublished report.
[341] Ibid.
[342] McSweeney, C *et al* (2009). UNDP Climate Change Country Profiles: Senegal; http://adaptation-fund.org/system/files/AFB.PPRC_.2.4%20Proposal%20for%20Senegal.pdf and
[343] Adaptation Fund (2010): http://adaptation-fund.org/system/files/AFB.PPRC_.2.4%20Proposal%20for%20Senegal.pdf
[344] United Nations Development Program [UNDP] and Government of Senegal (2009). Project description "Senegal - Supporting Integrated and Comprehensive Approaches to Climate Change Adaptation in Africa." New York: UNDP and Dakar: Government of Senegal.
[345] Dennis et al. (1995 in Adaptation Fund, 2010)
[346] Adaptation Fund (2010): http://adaptation-fund.org/system/files/AFB.PPRC_.2.4%20Proposal%20for%20Senegal.pdf

The government of Senegal has identified salt water intrusion, coastal zone inundation, drought, low water flows, storm surge and extreme temperatures as its main climate-related hazards.[347] Its NAPA and Second National Communication[348] have identified three pillars in which it intends to focus its adaptation priorities and needs.

- The first pillar seeks to address climate change impacts by encouraging the transfer of appropriate technologies.
- The second pillar aims to reinforce actions that prevent and mitigate climate change impacts by enhancing social protection through disaster risk management, improving living/housing conditions and addressing health related issues through measures such as health insurance.
- The third pillar seeks to promote sustainable management of natural resources in water, agriculture, coastal zones, fishing and forestry.

The government is active in implementing adaptation projects both at a national level and through participation in regional initiatives such as the "Climate Change Adaptation Project in the Areas of Watershed Management and Water Retention", which has been financed from the UNFCCC Least Developed Countries Fund (LDCF). It is yet to receive funding, however, for NAPA-listed projects that target coastal protection and the development of agro-forestry.[349] Funding has also not yet been made available for activities to raise awareness and improve education for decision-makers or for the incorporation of climate change considerations in other national development strategies. However, a number of small-scale projects which address local problems related to the effects of climate variability have been implemented in areas such as reforestation, soil restoration, dyke construction, irrigation, mangrove restoration, and in the development of risk and disaster management plans that respond to floods in urban areas.

Senegal has benefited from regional initiatives such as the "Adaptation to Climate Change in West Africa" (ACCC) programme (funded by UNDP and implemented by UNESCO) and the UNDP/UNEP Climate Change and Development Initiative's "Adapting by Reducing Vulnerability Project" (CC DARE).[350] However, although this has been identified as a priority need, no early warning system or related project is currently underway in the country. As a majority of Senegal's population lives along the coast, this is of high importance.

[347] MEPN, (2006)
[348] MEPN, (2010)
[349] Ministry of the Environment and Nature Protection (Ministère de l'Environnement et de la Protection de la Nature) [MEPN] (2006). Plan d'action national pour l'adaptation aux changements climatiques (NAPA). Dakar : MEPN.
[350] Adaptation Fund (2010): http://adaptation-fund.org/system/files/AFB.PPRC_.2.4%20Proposal%20for%20Senegal.pdf and Ministry of the Environment and Nature Protection (Ministère de l'Environnement et de la Protection de la Nature) [MEPN] (2006). Plan d'action national pour l'adaptation aux changements climatiques (NAPA). Dakar : MEPN.

Senegal plays host to a number of local and regional institutions including some that produce climate projections, estimate consequences of changing climate and/or identify adaptation actions. Environnement et Développement du Tiers Monde (ENDA-TM) is one such network, which provides support for adaptation and currently hosts the AfricaAdapt framework (see Box 4-6: AfricaAdapt). InfoClimat (INFOCLIM) is another institution based in Senegal, whose aim is to share knowledge between stakeholders, disseminate research data and build awareness of climate change (see Box 4-7: InfoClim). The Council of Non-Governmental Organizations to Support Development (CONGAD) builds linkages between people and institutions specifically targeting NAPA outcomes, while l'Institut Sénégalais de Recherches Agricoles (ISRA) is interested in modeling climate change responses in rural areas through its Office of Micro-Economic Analysis.[351] The Centre de Suivi Écologique has been accredited as a National Implementing Entity by the Adaptation Fund Board. There is therefore no lack of institutions that are concerned with climate change-related issues in Senegal. The structures of these networks suggest that a wide variety of stakeholders has been accommodated in information and knowledge sharing activities.

Box 4-6: AfricaAdapt: knowledge sharing for adaptation

AfricaAdapt has been set up collaboratively by the Institute of Development Studies (IDS) at the University of Sussex, ENDA-Tiers Monde, and the Forum for Agricultural Research in Africa and the IGAD Climate Predictions and Applications Centre. It is an independent bilingual network (French/English), launched in 2009, that is focused exclusively on Africa. Its aim is to facilitate the flow of climate change adaptation knowledge for sustainable livelihoods between researchers, policy-makers, civil society organisations and communities that are vulnerable to climate variability and climate change across the continent. This distributed community of practice (CoP) is supported by a website that lists face-to-face events and allows members to upload their profiles and showcase their work. AfricaAdapt is animated by four network conveners (called knowledge officers), one from each of the main partners. It periodically publishes the briefing document *Joto Afrika* that is distributed throughout its network.

AfricaAdapt offers incentives to members to publish and develop their specific adaptation projects in the form of small grants. It incorporates many of the functions required of a successful community of practice in that it is driven by informed and active animators, uses both virtual and face-to-face knowledge exchange to build community engagement, provides access to moderated case studies and other information, communicates with both active and passive members (through *Joto Afrika*), and provides funding that enables members to develop and disseminate their knowledge both locally and internationally.[352]
AfricaAdapt's geographic focus extends beyond Senegal into the Francophone region of the continent including West, Central and some North African countries. Its online platform enables knowledge-sharing between knowledge workers and different members of the community of practice. Over a thousand members were registered as at April 2011, with some activities already realised and others underway. The second phase of the project, which began in 2011, uses a more granular form of networking called "Meet and Greet." This involves informal events at which diverse stakeholders who otherwise have no platform for engagement - including local decision makers, community representatives, researchers, students and journalists –, are invited to meet and share information about their projects and activities. These events have been successful in creating cross linkages

[351] UNDP and Government of Senegal (2009)
[352] See: http://www.africa-adapt.net/AA/

between stakeholders and sectors, for example by enabling those who are active in the agriculture sector to share policy-related information with people who work in other policy domains. So far, there have been ten Meet and Greet events held in different locations in East and West Africa. Some of these have brought together participants from a single country, while others have been regional, such as one held in the first quarter of 2011 in Addis Ababa. That regional event brought together over a hundred climate change stakeholders from across the African continent.

The Innovation fund is another component of AfricaAdapt's implementation strategy. A sum of between $6,500US and $10,000 can be allocated to any community-based project that promotes the practices of adaptation and knowledge-sharing within communities. Over 500 responses were received from recent calls for proposals for activities such as theatre, dance, music and film productions supporting adaptation. However, only ten responses were funded. While the innovation fund has potential value in getting local communities to link climate change to other development related concerns and to create reflection that produces economically viable initiatives, its lack of resources and the low number of projects it funds annually undermines these potentials.

ICTs play an important role in the dissemination of stories, information and knowledge on adaptation. While local communities may not have direct access to the internet, AfricaAdapt has been able to solicit their stories, visit them in the field, and update its online site with their information. Once information has been uploaded, a larger audience can gain access to knowledge of adaptation action which has taken place in a local community/village, which would otherwise not have been distributed as widely. Global audiences are granted access to local projects. However, it should be remembered that not all local initiatives are necessarily successful. The value of this kind of information dissemination is necessarily greater if it is accompanied by some kind of independent evaluation of the impact which individual initiatives have had.

The ease with which videos can be made and uploaded has encouraged the production of more story-telling multimedia content. Videos are useful as advocacy tools for policy- and decision-makers. Although a good deal of relevant content is available on YouTube, the context of most of that content differs markedly from those of local communities in Africa. AfricaAdapt encourages and empowers communities to create their own stories and videos. One example illustrating how communities have been encouraged to understand the complexities associated with climate change is the use of Radio Ada, a community radio station in Ghana. Using the radio as an entry point to the community was of great importance as the station had established the trust and confidence of its listeners. It would have been more difficult without this to build a relationship with the community. Through radio content, communities were encouraged to relate climate change impacts to other development issues, identify better ways of articulating the impact of climate variations on their lifestyles, and create local strategies that could help them to adapt. AfricaAdapt is considering the use of community radio stations in its second phase because practitioners recognize it as a "powerful tool in West Africa."[353]

[353] Interview with Henri Lo, Program Manager, IDRC (Held, April 20, 2011)

Box 4-7: InfoClim[354]

InfoClim is a project to address gaps between the adaptation practices of local actors and local government development plans which have been developed by policy makers. It is implemented in three rural communities – Thiès, Fandène, and Taiba Ndiaye Keur Moussa – in the Thiès region of Senegal, which is approximately 50 kilometers north of the capital Dakar. It is hosted by the Centre de Suivi Ecologique (CSE), an IDRC initiative. CSE has had extensive working relationships with its three client communities for over ten years, holding fora in the region on joint resource and infrastructure management, the testing of land conflict management and collaborative planning prototypes and tools.

InfoClim's activities include the establishment of an observatory on climate change which will be accessible to local and national stakeholders including but reaching beyond its members. It aims to conduct research on climate change perceptions in different communities, develop and expand existing national and regional environmental data, involve the local community in activities such as monitoring and early warning, and provide information that aids community adaptation to climate change.

The project has multistakeholder participation. It is being implemented in partnership with Green Senegal and the NGO umbrella body, FONGS, which works with many communities in agriculture and natural resource management; with CERAAS/ISRA, which provides knowledge on drought, irrigation techniques and adaptation strategies; and with the Laboratory of Atmospheric Physics (LPA) of the University of Cheikh Anta Diop (UCAD), which works on the modeling of climate scenarios for the Sahel in general and Senegal in particular, and which monitors the correspondence between local observations and predictions of global climate models, calibrating these models for local conditions.

The strength of these institutions in Senegal may be contributing to an enabling adaptation environment in the country by building the adaptation capacity and addressing the drivers of vulnerability which were described in the framework set out in Chapter 1. A National Committee on Climate Change (COMNAC), which reports to the Minister of State, has been set up to raise the climate change awareness of different groups, including the private sector, civil society, decision makers and academics. A subcommittee on Adaptation has been proposed within this National Committee.[355]

4.2.4 Programmatic approaches and opportunities for ICTs

The government of Senegal's recognition of technology transfer as a pillar of its policy is an indication of its commitment to use ICTs to address the impacts of climate change. It also suggests the possibility of redefining ICT use in policies, for building local technical capacity in the use of tools and applications, and for creating platforms for knowledge and information exchange. Information and knowledge sharing activities at a certain level have been implemented by CCAA and other local initiatives to narrow communication gaps. However, more needs to be done, especially in coordinating the knowledge that is

[354] http://www.cse.sn/seninfoclim/index.html, accessed September 2011

[355] The role of the COMNAC was discussed in stakeholder meetings with: El Hadji Mbaye Diagne- President of COMNAC (UNDP and Government of Senegal, 2009).

generated and the ways in which information is shared. A number of international institutions[356] already provide online data and information, guidance and knowledge-sharing platforms for adaptation purposes. [357]

Interviews were conducted with a number of stakeholders as part of the "deep dive" assessment in Senegal for this study. These included the government representative to the UNFCCC, the climate change program officer at the regional office of IDRC, AfricaAdapt knowledge officers, the director of a regional media NGO (the Panos Institute of West Africa), the representative of the UN Economic Commission for Africa's (UNECA) African Climate Policy Center; and the program officer at IEDAfrique, a local organization working on climate change adaptation. These interviews focused on two broad sets of questions:

A. *How is knowledge regarding adaptation to climate change (e.g. vulnerabilities and practices for reducing vulnerabilities) being shared within Senegal? How is the government communicating the need to adapt, and what adaptation actions can be taken? What is the role of NGOs in this process? What are development organizations – the UN bodies, NGOs, and others – doing? What communications mechanisms seem to be most effective? Are ICTs being used in the process? Where are the barriers and opportunities?*

B. *How are government officials, NGOs, development assistance officers and others who are responsible for implementing adaptation policies and programs learning about new science and other knowledge, adaptation practices* etc*. which are taking place outside of Senegal? What is working best for them in terms of knowledge sharing? What is the role of ICTs, if any, in these effective mechanisms? Which ICTs seem to offer the greatest potential? What are the barriers to be overcome?*

The following observations resulted from these interviews:

- At present, information- and knowledge-sharing about climate change in Senegal is fragmented – this in a domain that is already highly segmented. Networks have been created at various levels, and different methodologies are being implemented for knowledge- and information-sharing by the groups described in the previous section, most of which do not intersect with one another. The government, for example, has developed information sharing networks comprising representatives from government departments, the private sector, the research community and international organizations. AfricaAdapt and its host organization ENDA-TM maintain a network

[356] The Global Environmental Foundation, the United Nations Development Fund, and the World Bank have supported the development of online tool sets for knowledge and information sharing for adaptation.
[357] Paas, L., Hamill, A. (2010). *A stocktaking of web-based knowledge platforms for the integration of climate change adaptation into development policy-making and planning.* IISD [DRAFT]

of stakeholders that includes community-based organizations, media, and environmental researchers. This is similar to, but distinct from and less interactive than InfoClim's network.

- Community-based organizations proactively find their own channels for communicating internally, using local media and village town hall meetings, which are seldom attended by a designated local government official. This fragmented state of affairs augurs badly for collaborative activity and for information- and knowledge-sharing between communities, institutions, and even countries with similar situations and experiences across the region. Thoughtful application of ICTs could be used to manage such inter-relationships by facilitating collaboration between stakeholders and developing meta-tools for interconnection between platforms.

- Another level of complexity is evident beyond the national context where various other tools, networks and applications have been implemented with a variety of objectives. Several platforms have been used globally and in Africa for climate change knowledge- and information-sharing. Table 4-1 identifies five of these which are frequently used, while a more complete list can be found in Appendix 6. These offer many different climate change adaptation resources, are maintained dynamically, make use of new Web resources such as social media, and focus on specific topics and/or the needs of particular geographic areas or stakeholder groups. They were, however, described by interviewees as being difficult for users to navigate, rarely interoperable between platforms, and seldom focused on fundamental methodological challenges such as adaptation planning. Interviewees felt that they did not address adaptation systematically and that their broader, regional geographic focus was not always helpful for specific countries.[358]

Table 4-1: Knowledge platforms for sharing climate change adaptation information

Knowledge Platform	Platform Host(s)
Africa Adapt	IDS
Adaptation Learning Mechanism (ALM)	UNDP/GEF
Climate Adaptation Knowledge Exchange (Cake)	Island Press/EcoAdapt
Climate 1-Stop	IAGT/USAID
Climate Change Data Portal (WB Climate Change Portal)	World Bank

While ICTs have been used, the interviews for this study suggest in short, they require refinement and would benefit from more homogenous application. Adaptation projects in Africa should connect actors with communities on the ground. There are opportunities for greater harmonization of the various

[358] Email correspondence with Paas, L., summarizing key findings from Paas and Hammil (2010) IISD review of knowledge sharing platforms for adaptation to Climate Change. IISD

systems available, for greater collaboration among stakeholders, and for systematic application of communication approaches that draw together the various national and regional networks and in-country hierarchies that have become established.

There will be challenges to this approach, one of which concerns incentivising collaboration. Practical incentives for the exchange of information among stakeholders are needed at two levels: incentives that encourage the sharing of information and better synergies at the level of platform/content creators; and practical activities that build links among practitioners at the level of communities. Meaningful learning from knowledge exchange requires motivated individuals and committed facilitation.

Another layer of complexity results from the cultural importance that face-to-face meetings have in the local context. Although physical networks and "expert gatherings" are held to share knowledge and information, little evidence is visible of the application of knowledge shared over these platforms. There remains a disconnection between platforms, networks and grassroots adaptation activities. Specific actions are needed to address this. One of these is greater recognition for local gatherings as an efficient platform for knowledge and information sharing. Another is the development of communication channels through which experience can be shared, enabling communities to benefit from one another's experience. More effective synergies are needed between stakeholders (local communities, researchers, adaptation platforms – Africa Adapt and InfoClim, government, development and international financial institutions). ICTs offer an opportunity for bridging these gaps.

A further challenge concerns the adaptation of research rhetoric to meet the needs of local people. Current models like AfricaAdapt have value here, as do other initiatives that use community-based journalists and others to broker information between researchers and local communities. A more systematic approach is needed, however, to leverage indigenous knowledge and repurpose it for the Web and virtual online communities. This would be time-consuming and resource-intensive, but could add considerable value.

With a vibrant telecommunication sector and high mobile subscription rate, Senegal could leverage the internet and mobile services to expand knowledge- and information-sharing to rural dwellers, farmers and fisherman who need them. It could also gain from the use of ICTs in the deployment of early warning systems and in the monitoring and distribution of climate data. A few initiatives in the country, such as the Manobi Project,[359] already use mobile phones to disseminate market price information to farmers and other information to different groups of citizens. Similar approaches could be applied for distributing climate data. The value of such initiatives depends on the quality of networks and the ways in which individuals use their mobile phones. ICTs such as sensor networks and remote sensing

[359] Manobi's Xam Marsé product will automatically send an SMS each day with information on the latest prices and availability of a favorite product in the market, to which you have subscribed (push). The service could also be used to request the current value of a recently sold or purchased product (pull). http://www.manobi.sn/sites/sn/

equipment could also be used to address the information gaps discussed above, and to generate more data on climate factors, which are currently insufficiently quantified in Senegal.

4.2.6 Summary

The most important points that emerge from this review of the climate change and ICT landscape in Senegal are as follows:

- Climate projections in Senegal are hampered by a lack of information resulting from insufficient daily temperature observations being taken to identify trends in temperature extremes.
- The government of Senegal has identified three pillars on which to focus its adaptation priorities and needs. These seek to address climate change and its impact, and are focused on technology use and transfer. This presents an opportunity for the use of ICTs for adaptation through the introduction of supportive policies, the development of technical capacity and the application of new technologies for monitoring, alerts, mapping and data generation. Appropriate applications would include sensor networks, remote sensing applications and early warning systems that address current gaps.
- As host to a wide variety of local, regional and international climate change focused institutions, Senegal is well-placed to benefit from information and knowledge that are systematically shared and that can be applied in local communities. Information-sharing about research outcomes, community experiences and successful activities in different communities with similar circumstances can be effectively enabled using ICTs.

The widespread deployment of telephone (including mobile) infrastructure presents an opportunity for the installation of ground station equipment, data capture and generation, and the installation of monitoring devices including sensor networks. The shortage of data currently available suggests the need for an overhaul of the entire information management production line, including the generation of data, its transmission, storage and management, sharing and dissemination.

4.3 Malawi

4.3.1 Introduction

Malawi is a landlocked country located in Southern Africa, bordered by Zambia to the west, Tanzania to the north and Mozambique to the south and east. Malawi has a tropical climate, is cooler in the highlands with two seasons – rainy, from November to May, and dry from May to November. Lake Nyasa, 850 km long, spans a large proportion of the country from Karonga on the North to Monkey Bay,

south-east of Lilongwe the capital, and contributes to its total country water coverage of 24,404 sq. km[360] representing a fourth of its land mass of 118,484 sq. km.[361] Of the land availabled, 20.68 percent is used for arable of which 1.18 percent is taken up by permanent crops and 560 sq. km is irrigated. The total renewable water resource is 17.3 cu. km.[362] the contribution of agriculture to GDP fell from 55.2 percent in 1979 to 25.1 percent in 1994 and was 30.5 percent in 2009.[363] The urban population is just 20 per cent out of thirteen million people.[364] The major cities are experiencing only marginal rural to urban migration.

Malawi's teledensity was at 24 subscriptions per 100 citizens in early 2011, with high mobile tariffs and taxation contributing to this low level of telephone penetration. The telecoms market is unstable with litigation and indecisive regulation. Box 4-8 describes the country's ICT landscape.

[360] https://www.cia.gov/library/publications/the-world-factbook/geos/mi.html, last accessed, May 2011
[361] http://www.malawi.gov.mw/, last accessed, May 2011
[362] https://www.cia.gov/library/publications/the-world-factbook/geos/mi.html, last accessed, May 2011
[363] http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS/countries/MW?display=graph, last accessed, May 2011
[364] http://www.malawi.gov.mw/, ibid

Box 4-8: Malawi's ICT context

Malawi is one of Africa's least developed countries, and suffers from significant skill as well as investment constraints. Its telecommunications environment is less advanced than most in Africa, indicating a limit to the extent to which telecommunications networks can be relied upon at present for implementation of innovative applications and as media for mass communications. In Malawi, for example, a greater role may need to be played in climate change adaptation work by broadcast radio.

Mobile subscription teledensity in Malawi was around half the African average, at 24% in early 2011. Mobile coverage was provided by two companies, Airtel and Telecom Networks Malawi, while a third mobile license, issued in 2008, remained inactive and was then the subject of court action. A fourth licence had been awarded, withdrawn and retendered. The government had also decided to introduce a converged licensing regime which would allow the two fixed operators – the former incumbent Malawi Telecom and Access Communications – to enter the mobile market (both had previously been restricted to CDMA fixed wireless services). Mobile tariffs in the country are high and not helped by high levels of taxation on mobile use.

There were 15 Internet Service Providers in Malawi in early 2011, but limited availability of networks and the high cost of international bandwidth have kept broadband prices high. Malawi depends mostly on satellite access to the internet. The development of national infrastructure to connect it to the new international submarine cables along the continent's east coast has been slow and the necessary transit links through neighbouring countries remained incomplete as at April 2011. Once they are completed, and provided that there is appropriate regulation, this should reduce the cost of international bandwidth, reduce internet prices and enable greater use of broadband services (though these are likely to be limited in the near and medium term).[365]

There have been significant policy weaknesses concerning telecommunications in Malawi. The incumbent operator was not privatised until 2006, and there have been problems with the award of new licences throughout the period of restructuring. The regulator MACRA has limited human capacity, a common problem in the country. Few government departments make extensive use of ICTs or have websites, while officials are reported to be using webmail rather than government email systems for official business.[366]

4.3.2 Malawi's climate change context

Malawi's vulnerability to climate change is exacerbated by extreme poverty, poor infrastructure, limited credit opportunities, food insecurity, the spread of HIV/AIDS and poor health conditions.[367] The country relies on rain-fed agriculture, and recent droughts have caused poor crop yields or complete crop failure. Flooding has also compromised food production. Climate change is expected to affect infant malnutrition adversely and to foster ailments associated with malaria, cholera and diarrhoea which are linked to droughts and floods.

[365] http://www.budde.com.au/Research/Malawi-Telecoms-Mobile-Broadband-and-Forecasts.html.
[366] http://www.biztechafrica.com/section/government/article/malawi-fails-link-its-ict-policy/483/
[367] IISD (in print), *Adaptation Review of Current and Planned Adaptation Action: Southern Africa*, first draft (April 2011), unpublished report.

Malawi's electricity supply comes mainly from hydroelectricity generated by the Shire River, whose flow has been adversely affected by droughts and floods as well as by siltation. Droughts and floods are also adversely affecting the fisheries sector, and have been responsible for the decline and/or drying up of water bodies, causing disruption to the quality and quantity of water available and loss of biodiversity. Increased incidence of drought is expected adversely to affect animal reproduction systems and migratory habits. Extended droughts, leading to land degradation, lower soil fertility and forest fires, are expected to be the main impacts of climate change on the country's forestry sector.

4.3.3 Policy responses and actions to climate change

Malawi's NAPA has identified a number of priority adaptation activities, following a process of evaluating their technical feasibility, economic impact, effects on vulnerable groups, cost, level of stakeholder participation, and other cross-cutting issues. Studies have shown that there is a need for diversification in crop varieties that are suited to future climate conditions, as well as for efforts to improve land use practices, invest in reforestation, enhance local government capacity, improve sectoral coordination, enhance climate data collection and modeling, establish risk management and safety procedures, and strengthen policy frameworks.[368] The NAPA also discusses barriers that inhibit the implementation of adaptation actions, including extreme poverty, poor infrastructure, limited availability of credit, food insecurity, the spread of HIV/AIDS, poor health conditions, and limited research and analytical capacity.

Five priority adaptation projects are identified in Malawi's NAPA. These focus on capacity-building and community-based adaptation initiatives in agriculture, forestry, electricity, disaster risk reduction and meteorology. The five projects seek to:

- improve community resilience to climate change through the development of sustainable rural livelihoods;
- restore forests in the Shire River Basin to reduce siltation and associated water flow problems;
- improve agricultural production under erratic rains and changing climate conditions;
- improve preparedness to cope with droughts and floods; and
- improve climate monitoring capacity so as to enhance early warning, decision-making and sustainable utilization of Lake Malawi and lakeshore area resources.

A significant number of adaptation projects are currently being implemented in Malawi, considering the country's size, population and economic challenges. The majority of these are in the agriculture sector – concerned with helping smallholder farmers to understand and anticipate climate risks, crop

[368] ActionAid (2006)

diversification, food security, and water use. There are also initiatives concerned with policy integration and formulation at the community and national levels. Only a minority of these projects include ICT-related activities, such as improved meteorological data, and the use of media and communications facilities to collect and disseminate information.

Malawi participates in a number of regional adaptation initiatives, including a Climate Change and Development program funded by the Danish aid programme, the Japan-UNDP Africa Adaptation program and the IDRC-DFID Climate Change Adaptation in Africa program. One of its NAPA priority adaptation projects has been funded by the UNFCCC Least Developed Country Fund (LDCF). Other donors include the Norwegian and Spanish governments, the German development agency BMZ and USAID, as well as multilateral organizations.

Despite the significant number of adaptation activities currently underway in Malawi, there are important gaps in adaptation work. The following paragraphs discuss some of the programmes currently underway, and the opportunities for ICTs to be used to facilitate these and other work.

4.3.4 Programmatic approaches and opportunities for ICTs

There is no shortage of climate change adaptation activities in Malawi. A large number of on-going projects address policy development, capacity building and challenges in specific sectors such as agriculture. A focus group of climate change actors was brought together in July 2011 as part of the "deep dive" study of the country undertaken for this project. This included participants drawn from the University of Malawi, the Ministry of Agriculture and Food Security, the UN Food and Agriculture Organization, the Malawi Commission for Science and Technology and the Department of Climate Change and Meteorological Services. Its objectives were to:

- conduct a stocktaking of emerging and existing good practice implementations of ICT use for adaptation;
- identify barriers and constraints to successful implementation and the scaling up of activities;
- prioritize climate risk options, policies and programs with potential for ICT use; and
- identify adaptation actions in the area of water management.

The focus group identified research initiatives, capacity-building activities in policy and practice, knowledge repositories and directories, and climate monitoring and early warning implementations.

One significant joint research project focuses on the strengthening of local agriculture innovation systems to adapt to challenges and opportunities arising from climate change and climate variability,[369] particularly through a five year capacity-building project of agricultural conservation in the Lake Chilwa Basin area.

Regional activities from which Malawi benefits, such as ClimAfrica, target water resources, agriculture, ecosystem vulnerability, and the development of a long term monitoring and forecasting system for food security and risk management. ClimAfrica also aims to analyze the economic impacts of climate change on water and agriculture.[370]

Capacity-building activities which benefit Malawi are not usually confined to the country alone, but undertaken in regional partnerships which enable inter-country collaborative knowledge- and information-sharing. One activity is the Capacity Building Adaptation to Climate Change Project which seeks to develop research and teaching capacity for climate change adaptability and vulnerability in universities. International development organizations such as FAO, the World Bank and UNDP[371] are providing technical support through this project to governments and other stakeholders involved in implementing national programmes including Malawi's National Programme for Managing Climate Change.[372] The Ministry of Agriculture and Food Security is benefiting from the Sector Wide Approach (SWAp) programme which focuses on breeding resistant and early maturing crop varieties.[373] The Ministry is also collaborating with the Department of Meteorology and Climate Change to improve weather forecasting in a project that installs automated weather stations around the country. This move could potentially result in the production of data that can contribute to the improvement of crop estimates, and to address the capacity requirements needed to record weather information.

The National Commission for Science and Technology (NCST) is developing two online directories – one for science and technology institutions in Malawi, the other for researchers dealing in science, technology and innovation research, including those who are working in the area of climate change

[369] The research is undertaken by Institute of Resource Assessment (IRA) of the University of Dar es Salaam, Natural Resources and Environment Centre (NAREC) of the University of Malawi, and the Natural Resources Institute (NRI) of the University of Greenwich, UK

[370] http://www.climafrica.net/index_en.jsp

[371] FAO is supporting the Environmental Affairs Department (EAD) in developing the media-based communication programme on climate change and a communication website to be used by all stakeholders implementing climate change programmes. FAO is also supporting Bunda College and the Department of Agriculture Extension Services (DAES) to develop a training manual on accessing and using information about climate change and adaptation options. The manual will be used for training District Executive Committees, traditional chiefs and other local leaders as well as facilitators of field schools and on-farm demonstrations.

[372] Malawi Climate Change and Environmental Programmes, http://nccpmw.org/index.php?option=com_content&view=article&id=63:malawi-climate-change-programme&catid=38:environment

[373] Malawi Focus Group Event (2011). Stakeholders at a focus group event held in July 2011 involving government, academia, civil society and community participants indicated their unawareness of the various activities that was happening across the country, most of which they can directly benefit from or contribute to.

adaptation. To address connectivity and internet challenges, and to improve communication between researchers, the Malawi Research and Education Network (MAREN) is developing a secure high-speed national data communications backbone that will interconnect research and education institutions in the country and connect them with other regional research and education networks in East and Southern Africa.

Malawi's adaptation project priorities recognize the need to improve climate monitoring, enhance early warning and develop decision-making capability that enables the country to improve sustainability in the use of lakeshore resources. Projects in each of these areas could benefit from the use of ICTs, for example in providing timely information to riparian fishing and farming communities on disaster preparedness and on short and long term adaptation livelihood skills.

A few locally-initiated projects had been deployed to address the challenges of deforestation, soil erosion and river sedimentation. One example is the participatory GIS project described in Box 4-9, which seeks to build local adaptation capacity in water management. This aims to enhance the response capacity of local communities by addressing the drivers of vulnerability which they experience. However, there are relatively few examples like this in these policy and practice domains. While agriculture-related initiatives and capacity-building can help to address climate change challenges in other sectors, more initiatives are needed that specifically target these issues. Comprehensive adaptation work in the country needs to achieve a more holistic and broadbased approach.[374] A coordination mechanism is needed to help the government and other stakeholders to address project gaps, identify and disseminate lessons learned from existing activities, and ensure that future investments are targeted on areas where there is the greatest need.

[374] Malawi Focus Group Event (2011). *Ibid*

Box 4-9: Participatory Geographic Information Systems (PGIS)[375]

Mangochi is an old town set on the west bank of the Shire River, which flows between Lakes Malawi and Malombe, and is close to important forest reserves and nature parks.[376] [377] Using Participatory Geographic Information Systems (PGIS) and problem tree analysis, deforestation has been identified as a major environmental problem that has left much of the area's customary land bare, leading to soil erosion, loss of soil fertility, siltation of rivers and water holes, loss of biodiversity and flooding in low lying areas around the Malombe and Shire Valley (LEAD, 2011).[378]

The PGIS project established to address this was conducted in a study area of nine village communities that are within 500 meters of a water body (as stipulated by the National Water Policy), and 2000 meters of a source of fuel for food supply. Its objective was to engage government officials and local communities in the process of participatory decision making for environmental and natural resource management. It aimed, through this, to establish a baseline assessment and to investigate climate change adaptation strategies concerned with access to forest resources, food security and the availability of water for irrigated agriculture and domestic consumption.[379]

As part of the programme's work, communities were trained and required to map their villages using GPS devices, to generate maps of their own communities, and to create a centrally located model that can be used to determine current and future water needs. The outcome of the project suggested that men produced less detailed maps than women, who more precisely located fuel, water, forestry and areas prone to floods and droughts. The exercise illustrated the extensive knowledge of the immediate local community as well as its susceptibility to the impacts of climate change or variability. Communities were empowered by the initiative which improved their understanding of the presence or lack of resources in their immediate surroundings, of climatic variations and of approaches to developing communal adaptation strategies, including long-term strategies. It also improved communities' capacity to negotiate with government agencies over issues such as the location of water points.

Appropriate use of ICTs can help to improve the coordination of these activities. The establishment of online directories by NCST is a step in the right direction, but more needs to be done to distribute knowledge and solicit expertise. Simple activities such as the creation of a national email discussion list among actors for the sharing of research, community knowledge and project information would help until a more comprehensive coordination mechanism has been established.[380]

The impacts of climate change or climate variability appear sudden. ICTs can be used to monitor sudden events as well as to improve weather forecasting and climate modeling. This is an area that has been identified in government's priorities and where some activity has been taking place. However, more widespread engagement is required.

[375] The PGIS project was undertaken by LEAD Southern and Eastern Africa (LEAD-SEA) and funded by IDRC.
[376] http://www.wawamalawi.com/south-mangochi, last accessed August, 2011
[377] http://www.zgf.de/?projectId=9&id=65&language=en, last accessed, August, 2011
[378] LEAD, (2011). *Participatory Geographic Information system: Baseline studies report, Malawi.* LEAD Southern and Easter Africa.
[379] LEAD (2011)
[380] Recommendation by participants at a focus group event held in July 2011 on climate change adaptation activities in Malawi.

Capacity-building challenges are evident in Malawi which calls for more broadly based approaches than those which are intended for policy-makers alone. It is important, too, that policy makers, practitioners and researchers keep pace with the rapid development of available technologies. One useful approach to addressing long-term knowledge gaps would be the inclusion of climate change studies in primary, secondary and post-secondary curricula, as well as in teaching and research at higher levels. Measures to help local communities, public and private media to disseminate information and convey awareness of climate change would also be valuable.

Limited data availability is a particular constraint in addressing climate change in Malawi. Climate data, particularly from the government Department of Climate Change and Meteorological Services, are rarely available to researchers and other agencies that need them. More research capacity is also needed in the country. Much of the research that is conducted relies on external expertise, though there are initiatives that encourage student exchanges between countries. However, the non-availability of data undermines the effectiveness of research activity. Programs such as the Open Data Initiative[381] that allow governments to offer national data for research purposes could help to address these constraints.

4.3.6 Summary

Outcomes from this case study of the climate change landscape in Malawi can be summarized as follows:

- Malawi's environmental challenges include deforestation, soil erosion, sedimentation and siltation. Its climate change vulnerabilities are compounded by poverty, poor infrastructure, limited credit opportunities, food insecurity, and reproductive and broader health challenges.
- The government considers the improvement of its climate monitoring capacity through the use of early warning system, enhanced decision-making capacity and sustainable use of lakeshore resources to be three important factors in developing its ability to address the challenges of climate change.
- A significant number of adaptation projects are being implemented in Malawi by a number of international development organizations, international financial institutions and local community based institutions. These focus on agriculture, research, capacity-building and support for policy development. Some of these projects could benefit the introduction of an ICT component.
- The relatively large number of adaptation-related projects in the country could benefit from better coordination which could be facilitated by ICTs. This would help to avoid duplication,

[381] http://data.worldbank.org/news/open-data-measures-progress, accessed December 2011

improve the availability of information, build capacity, and develop and share knowledge among stakeholders.

- Capacity-building challenges are evident among policy-makers, practitioners and researchers. Knowledge gaps need to be addressed through rigorously researched projects and the documentation of lessons learned from community-based initiatives. The introduction of relevant curricula and school programs at primary, secondary and post-secondary levels could help to address long-term environmental capacity requirements. Improvements in the capacity of the communications regulator MACRA are also needed.
- Despite the large number of projects involving monitoring and climate data generation in the country, there is a shortage of data by practitioners and researchers. Policies are needed to encourage the release of government meteorological data for research purposes, along with practical ICT channels to make them available.

4.4 Conclusions

This chapter has examined the broad climate change context and focused on cases where ICTs have been used:

- to help rural farmers in Uganda to adapt to climate change;
- to address the importance of online knowledge platforms for the sharing of knowledge for adaptation in Senegal and across Africa; and
- to examine the value of communally generated participatory geographic information system for water and resources management in Malawi.

In Uganda, the Seasonal Climate Forecast and Agricultural Producers, M-Pesa (described in Chapter 3) and the Community Knowledge Workers projects (CKW) are mechanisms for distributing weather and climatic information, weather and agricultural advisory guidance, and health information to communities and farmers via SMS (See Box 4-2, 4-3). Their application enhances the capacity of local farmers and communities to address the drivers of vulnerability and to improve their response capacity through the combination of microcredit schemes with local knowledge and information sharing capability. The development of information and knowledge sharing mechanisms such as AfricaAdapt and Infoclim (described in Box 4-6, and 4-7) in Senegal have somewhat contributed to narrowing the gap between research and practice by building a platform for which researchers and local communities can share knowledge. They align with information sharing and knowledge management systems needed to build response capacity. The participatory geographic information system (described in Box 4-9) and implemented in Malawi can lead to the development of locally involved and directed solutions to

climate change challenges which can contribute to capacity to manage risks. These applications are in consonance with the framework described in Chapter 1.

While the “deep dive” case studies reported in this chapter have been country focused, the findings that emerge from them have implications in the wider African context. In particular, they suggest the need for more extensive use of ICTs in four main areas:

- Strengthening existing meteorological services through the use of weather stations, sensor networks and remote sensing data. This is evident from all the countries studied for this chapter - in Uganda, where obsolete weather and climate data collection processes need to be replaced by more modern technology and more efficient and timely ways of disseminating information; in Senegal, where the lack of data collection infrastructure presents an opportunity to redesign meteorological information production and management processes and to introduce new facilities; and in Malawi, where policies that target information availability and open data for research purposes are required. These outcomes are consistent with the policy considerations in the framework described in Chapter 1.
- Building far-reaching knowledge- and information-sharing networks that make use of a variety of media including the internet, mobile telephones and community media facilities. These networks should include intermediaries or community knowledge workers who can broker information, acting as bridges between policymakers and local communities by explaining national strategies and plans at local level and clarifying issues and contexts for national policymakers where local adaptation interventions are required. More efficient partnerships, which draw on the resources of the private sector and other stakeholders, are required to extend information distribution and awareness of climate change issues within communities.
- Developing policy making capacity as well as research expertise to document local implementations of climate change applications. Although chapter 2 indicated some presence of capacity building activities, past and ongoing, there is substantial evidence, by the low numbers of documented and researched ICT-related climate change stories; that capacity building is required to: systematically conduct scientific research that will narrow the gap between policy and practice; and policy capacity, to narrow the gaps between practitioners, researchers and policy makers.
- Encouraging the development of policies, strategies and practice that support open data approaches to address the limited distribution of data where these have been collected. Where data already exists such as in Malawi, policies are required to make them available to researchers, practitioners, and decision makers. In countries such as Senegal where data may be limited, there is an opportunity for to develop policy and practice that encourage open data approaches.

Chapter 5 - Observations and Recommendations

One critical insight in the climate change field over the past decade has been the intimate connection between climate change adaptation and development. The vulnerability of a community or country to the impact of climate change is largely determined by its current level of socio-economic development. As a consequence, Least Developed Countries (LDCs) are considered to be among the most vulnerable to the impact of climate change. Their limited financial, institutional and human resources, high dependency on ecosystem-dependent economic and livelihood activities (such as agriculture, fisheries and pastoralism), and existing vulnerability to stress factors such as land degradation, disease and social conflicts reduce their capacity to respond effectively to current and future climate stresses. Tackling the root causes of poverty and promoting economic development while taking into consideration the potential impacts of climate change can therefore be viewed as a central objective of climate change adaptation efforts.[382]

Other insights related to climate change adaptation include:

- the need for adaptation planning and implementation to be undertaken in response to local circumstances and capacity;[383]
- the critical role of governments in creating an enabling environment in which autonomous adaptation can take place;[384]
- the need to begin by addressing current climate risks facing individual countries as these are likely to become more pronounced as climate change proceeds;[385] and
- the recognition that adaptation is a long-term, continual process that cannot be effectively undertaken separately from on-going development and governance processes.

Taken together, these factors point to the importance of integrating climate change considerations into everyday decision- and policy-making in order for climate change as a whole to be efficiently and effectively addressed in both short and longer terms.[386]

This conceptual understanding of the links between adaptation and development, and of the need for integration between them, has underpinned IISD's approach to assessing the potential role of ICTs in

[382] World Bank. (2010). The Economics of Adaptation to Climate Change: A Synthesis Report: Final consultation draft. Washington: The World Bank.
[383] See for example: Burton, I. and van Aalst, M. (2004). Look Before you Leap: A Risk Management Approach for Incorporating Climate Change Adaptation into World Bank Operations. Washington, D.C.: World Bank.
[384] Autonomous adaptation refers to adaptation action that is largely undertaken independently and informally, as opposed to being completed in a planned and formal manner.
[385] World Bank. (2010). Ibid.
[386] See for example: OECD (2009). Policy guidance on integrating climate change adaptation into development cooperation.

supporting adaptation to climate change. As discussed in Chapter 1 of this report, adaptation requires policymakers and practitioners to address the drivers of vulnerability and to build the response capacity of local and regional systems and communities. The general scan and more in-depth case studies in this report illustrate how ICTs can enhance the capacity of existing sectors to implement current and planned activities in a way that reduces vulnerability to climate change and helps to build resilience. In this respect, the practical application of ICTs for adaptation may differ little from their application for development more generally (for example in the use of geographical information systems for land use planning). However, adaptation also requires policymakers and practitioners to address climate risk more directly, through the identification and reduction of risks related to climate variability and climate change, and to confront climate change impacts, for example through improved monitoring capacity and emergency preparedness. What makes ICT applications supportive of adaptation is the degree to which they help to reduce climate risks and impacts in these ways.

This final chapter of the report presents recommendations on how ICTs can contribute to the transformation of Africa, with the aim of improving resilience and reducing risk and vulnerability to the impacts of climate variability and climate change.

5.1 General Recommendations

IISD strongly advises that the following three broad recommendations should be taken on board before governments and other stakeholders plan specific ICT investments to assist with climate change adaptation. These focus attention on the need for critical reflection on what constitutes adaptation, and on what work is already being done at the country level, to find the most appropriate mix of ICT and other interventions for each national and regional context.

1. **In planning future program interventions and investments in ICTs for adaptation, governments and other stakeholders should make use of the framework of intervention approaches which is set out in Chapter 1 of this study.**
   ICT interventions in climate change adaptation should be located within broader understandings of development and climate change analysis. IISD's proposed framework, which is set out in Chapter 1, consists of a simple matrix which aligns a spectrum of types of ICT interventions, from small scale to large scale, against the four major themes of the adaptation challenge. The first two of these themes are framed in the context of addressing development, the third and fourth are concerned with monitoring and responding to the physical impact of climate change itself. **Addressing development:** Framework areas of activity:

   1 – Addressing drivers of vulnerability and

2 – Building response capacity.

IISD's analysis suggests that the major areas for ICT interventions under these headings include the following:

- Reducing vulnerability by addressing the drivers of vulnerability. Governments and other stakeholders should pay particular attention to the development of IT systems that contribute to the improvement of health care, access to food and nutrition, and other social and economic drivers of vulnerability.

- Building the adaptive capacity of local and regional systems and communities**.** Governments and other stakeholders should pay particular attention to:

    - The water sector: managing water resources, including, among other activities, IT systems to support the management of water flows for irrigation and household water use; and the provision of information on controls over chemical use (pesticides, fertilizers), improved water harvesting methods and ways to reduce pollution.
    - The agriculture sector: implementing IT systems that enhance the adaptive capacity of farmers, rangers and pastoralists, including using climate and weather data to guide farming practices; providing information on better management practices, seed banks, new crops and crop varieties and alternative farming systems; and advancement of non-agricultural income-generating opportunities that may be IT related.

ICT interventions in other sectors (education, health, trade, agriculture, entrepreneurship, and so forth) that support general social and economic development may contribute serendipitously to adaptation, strengthening livelihoods and reducing dependence on current sources of income that may be vulnerable to the impact of climate change.

It is the application of a climate change adaptation "lens" when assessing current applications of ICTs in other sectors that provides an opportunity to identify those that have the greatest promise for contributing to adaptation-centered development today and in the future. But there is a major caveat here: attention also needs to be paid to whether ICTs deployed for a more traditional economic development application may in fact contribute to actions which are maladaptive or increase climate risk in the future. The challenge to consider is one of monitoring and assessment: How does one determine that longer term resilience and vulnerability reduction are in fact being achieved through these uses of ICTs for economic and social development? This monitoring and assessment challenge needs further consideration and research by national and international development agencies.

The third and fourth themes of the framework are framed in the context of climate risk arising from climate variability or climate change **Monitoring and responding to the physical impacts of climate change:** Framework areas of activity:

3 – Managing climate risk; and

4 – Confronting climate change.

The uses of ICTs for monitoring and responding to impacts have significant potential. These are areas that are still fairly new, underexplored and ripe for innovation in Africa IISD sees scope here for future interventions by the Transformation-Ready programme partners along the following lines:

- Developing climate change projections at national, regional and sectoral levels. Governments and other stakeholders should pay particular attention to investment in monitoring infrastructure and modelling systems to create projections of basic climate variables and their impacts on water, agriculture, health, *etc*.

- Addressing climate change impacts through risk reduction and management**.** Governments and other stakeholders should pay particular attention to investment in ICT systems to support three major areas:
    - urban planning (accounting for potential impacts of climate change, such as heavy rainfall causing localized flooding, sewage overflow, and housing destruction);
    - coastal management (monitoring the impacts of anticipated sea level rise including land loss, coastal erosion and damage to coastal infrastructure, and the loss of coastal and marine habitats) and
    - water resources management (smart systems for supply and demand management, including monitoring changes in water level fluctuations, promoting the re-use and recycling of water and the regulation of water use in peak hours).

- Creating and revising early warning systems. Governments and other stakeholders should pay particular attention to preparations for potential impacts of severe weather events, including floods, disease outbreaks, drought and landslides, and to the rapid and responsive delivery of disaster and emergency relief.

IISD recommends strongly that adaptation themes should drive decision-making concerning the use of ICTs in adaptation, rather than the ICTs themselves.

2. **Building the capacity for integrating ICTs into adaptation policy development will have significant benefits. Particular attention should be paid to including more detailed application of ICTs in National Adaptation Plans (NAPAs) in LDCs and adaptation planning efforts in other countries.**

As noted earlier in this study, current National Adaptation Programmes of Action (NAPAs) rarely include consideration of ICTs as integral components for adaptation. Traditional bureaucratic "silos" separate environment, climate change and adaptation policy makers and planners from those working on ICTs and telecommunications. IISD recommends that planned interventions should be undertaken to bring those responsible for adaptation policy and planning (particularly NAPAs) together with ICT/telecommunications government staff. These should review how ICTs are being considered in NAPAs and in other planning efforts, and work together for more effective planning and implementation on ICTs and adaptation in the future.

There is a particularly important window of opportunity here at present. The Cancun Climate Conference (COP16) "established a process for Least Developed Countries (LDCs) and other interested developing countries to formulate and implement national adaptation plans … to identify and address their medium and long-term adaptation needs. This builds upon the positive experience of LDCs up to now in addressing their urgent and immediate adaptation needs through similar plans which were supported via the LDC Expert Group."[387] The modalities for these "second generation" national plans (what they will contain, how they will be financed, *etc.*) are currently being negotiated. Working with LDCs now to understand the relationship between ICTs and adaptation may lead to better consideration and more inclusion of ICTs in this next round of national adaptation planning.

The capacity of policy- makers to understand the potential of ICTs in achieving adaptation objectives needs to be developed – a process that should include the private as well as the public sector. However, this must be done within the boundaries of a clear understanding of what is feasible within a national or regional context. Focusing just on the LDCs, one starting point would be to conduct a mapping exercise of current NAPAs against the framework developed in Chapter 1 for considering ICT use in the context of adaptation, followed by in-country working sessions with policy-makers, to consider what their priorities are and how the ICT tools that are available can help accelerate progress towards their achievement.

In line with the framework discussed in Chapter 1, there are some policy considerations that may be useful in this context. As it relates to small scale ICT implementations; policies that support the provision and affordability of access may be required – to leverage current mobile teledensity and to advance the usage of mobile applications – in order to build response capacity and to address the drivers of vulnerability. Likewise, policies in support of relevant communication strategies and public information mechanism that would further drive knowledge and information to areas where they may not hitherto have reached are also required. As it relates to Large scale ICT implementations, policies are needed in the area of infrastructure deployment for smart systems and sensor networks; open data approaches and data acquisition mechanisms for early warning, satellite and

[387] http://cancun.unfccc.int/adaptation/

remote sensing systems; and capacity building for policy makers, researchers and practitioners in the area of geographic information, global positioning and modeling systems. There may be the need for crosscutting policies in these areas.

3. Engaging with the ICT private sector

Engagement of the ICT private sector in climate change adaptation is less substantial and widespread than it is in mitigation, where the private sector is directly involved in developing clean technologies, energy efficiency, dematerialization to reduce carbon footprints and other areas of innovation. The scan of ICT applications undertaken for this study did not reveal private sector-led or public-private partnership opportunities that could be replicated. In the case study countries, workshop participants in Uganda and Malawi came predominantly from government, academic and development organizations rather than private enterprises. One respondent to the online survey distributed for this report highlighted the challenge of private sector involvement in environmental matters, particularly adaptation, suggesting that the absence of clear business and revenue generating opportunities in adaptation-related activities represented a deterrent for profit-oriented businesses. Another barrier is that adaptation is often perceived to be part of the government's responsibility to protect and support its citizens. As a result, governments themselves do not think sufficiently about what private sector opportunities might be available or about how to create the appropriate rules, incentives and programs to attract the private sector.

More work is needed to engage strategically with the private ICT sector, to review where privately motivated interests in applications could directly or serendipitously enhance adaptation while also delivering commercial value. The business case for private sector involvement in building out monitoring systems and other infrastructure requirements needs to be explored. It may be that the use of communications media for data and information sharing on adaptation will increase significantly, enabling services which generate revenue for mobile phone companies and Internet Service Providers.

While it may be possible to project revenue increases through increased demand, users themselves—the very people who need information – may not be able to afford the costs of ICT use. Sending SMS to receive adaptation information will add to the regular communications costs for mobile phone users. Farmers or other recipients of such information may be unwilling or unable to afford information especially if they have to access notices on a frequent basis. The cost of meeting other needs may surpass the need for adaptation information. Disaster preparedness and early warning information may be requested only when critical, and possibly when it is too late to reduce vulnerability. Solutions to the challenge of balancing communications costs for users with private sector interests in revenue generation may require governments/regulators to negotiate alternative

and less expensive pricing mechanisms for the distribution of climate risk related information. Adaptation is not, of course, the only development sector to which this observation could apply.

5.2 Specific Guidance to E-Transform Africa partners

In light of the above discussion, IISD recommends that the African Development Bank and its partners should focus their financial and policy investments in the areas discussed in the following paragraphs. These are grouped in three categories, as follows:

- those that are ICT-relevant, concerning frameworks, policies and planning;
- those that are ICT-centric, concerning investments in ICT infrastructure and tools; and
- those that are ICT-enabled, concerning support for the sharing of knowledge and action for adaptation.

1. ICT relevant policy interventions

a. ICT planning should be embedded in the adaptation planning processes that are already underway in most African countries. In particular, for the LDCs, the preparation of second generation National Adaptation Plans should be seen as a window of opportunity for the inclusion of ICT-relevant interventions. Preparation for these should include a capacity building program to review where and how investments in ICTs might be best integrated in these plans.

b. Access to data is a fundamental requirement for adaptation planning. Model policy frameworks and guidance could be developed for countries across Africa, with a view to making environmental and meteorological data open to all interests (public, academic, and private).

Rationale:

Consideration should be given to exploring how policies on open data systems at national levels may create an enabling environment for addressing the impact of climate change. To respond to climate variability and impact, data need to become more accurate and openly accessible. An open and shared data approach of the kind highlighted in Chapter 4 would address this concern.

Kenya provides a rare example of government commitment to make data available on open platforms. Other governments in Africa have not followed suit, and there is no pan-African agreement comparable to the Aarhus Convention in Europe for freedom of access to environmental information. Access to government data is not easy in Africa, while access to academic data at

African institutions is also problematic. “Mash-ups” with local knowledge of conditions are extremely rare. The African Development Bank and its partners should work with national governments across Africa to develop model policy frameworks for making environmental and meteorological data open to all interests (public, academic, and private).

2. ICT-centric investments in tools and monitoring infrastructure

There is considerable scope for the Bank and its partners to invest in tools and infrastructure that will have a direct impact on the knowledge of climate change impacts which is available to governments and other stakeholders, communities and individual citizens, and consequently on their ability to plan for adaptation. IISD specifically recommends investment in the following five areas:

a. Investment in working weather stations, and in strengthening meteorological services in general, in order to improve data collection and technical capacity, and to improve the availability, accuracy and timeliness of weather and climate information.
b. Investment in new infrastructure for sensor networks to assist with monitoring glacier retreat, water systems, sea level rise and ecosystem impacts.
c. Investment in strengthening the technical side of data sharing, at several levels, in particular:
    i. between countries, to ensure more consistent monitoring and assessment of climate change across regions; and
    ii. between data that is generated from large-scale systems and that collected at the local level.
d. Investment in partnerships between governments, universities and the private sector for research and development on the effective management and integration between data generated from large-scale systems, and that collected at the local level.
e. Exploration of the potential for wider scale replication of the DEWS project described in Chapter 3 which uses sensors to generate climate data, transmits the resulting information to a central hub where it is analysed, leading to evidence-based decisions and to alerts which can be received by end-users on their mobile phones in local languages.

Rationale:

Program investments and related technical training could address major gaps in ICT sensor network infrastructure and software, enabling better monitoring and communication of physical/environmental impacts of climate change across Africa**.** Within the framework proposed by IISD, this recommendation focuses first on large scale, national and regional ICT implementations to

collect monitoring data, in order to manage climate risk, but also recognizes the need for middle-level applications and their translation into low-tech local-access use and response.
At the large scale end of the spectrum of ICT interventions, there is a growing need to strengthen and expand working weather stations. New infrastructure for sensor networks is needed to assist with monitoring glacier flows, water systems and ecosystem impacts. ICT applications to track related outcomes - such as the spread of diseases and agricultural pests - are also needed. African public-private partnerships for research and development on sensor networks and related technologies may prove fruitful in this context, bringing together government, academic and private sector scientists and engineers to take new technologies into production and implementation.

This study has found that most national and regional implementations of ICTs concerned with adaptation take place at the extremes of the spectrum – they are either large-scale meteorological and satellite applications or low-scale applications which focus on vulnerability reduction through the use of cell phones for alerts or to disseminate information. Middle level applications of ICTs such as geographic information systems and modelling are still few in number and therefore represent an area of opportunity extend the use of ICTs for reducing vulnerability and improving adaptive capacity. There is a critical need for tools and training to help translate data from large scale monitoring systems into information that is immediately useful for policy decision making.

There also appears to be little inter-linkage between information that is generated from large scale-systems and that collected at the local level. Large-scale systems are perceived to contain more long term value at a higher policy level but to have little applicability to local contexts, while local applications are thought to focus on short-term impacts and address the needs of local recipients rather than the nation as a whole. These two types of information should be seen as complementary.

IISD recommends that policy and implementation should focus on the deployment of ICTs in five specific areas namely;

a) Early warning Systems/ Weather Management/Meteorological Systems/Satellite and Remote Sensing Systems;

b) Smart systems and Sensor Networks;

c) Geographic Information Systems/Modelling/Planning/Decision tools;

d) Knowledge Management Systems/ Information Sharing Systems/ Planning/ Decision tools; and

e) Mobile Phone Applications/General Packet Radio Systems (GPRS).

One example of a project which illustrates the potential of ICT tools is the DEWS project (described in Chapter 3), which uses sensors to generate climate data and transmits information via satellites to

a central hub where information is analysed, facilitating decisions created from support systems and enabling alerts to be sent to recipients' by mobile phones in a language they can understand.

(It is worth noting here in parenthesis that, even though English, Portuguese or French may be the official language of a country, ICTs present an opportunity for the provision of a middleware solution that facilitates the parsing of information from national to local languages so that it can be more easily used by local communities in the local context. The development of such middleware with text-to-speech and speech-to-text capabilities might improve the relevance and value of alerts.)

Web based knowledge and information systems and platforms could well benefit from applications that permit the dissemination of their content to mobile phones. Research and field experimentation into how mobile technology can interface with these systems and platforms would be useful.

3. ICT-enabled interventions

Adaptation policy makers and planners need to be able to connect with and learn from one another about what is working and what is not – and this knowledge exchange needs to be informed by real experience on the ground. As noted above, initial successes in exchanging research and experience among experts and practitioners suggest that more could be achieved in this area. Two major gaps need to be addressed:

a. Mechanisms for sharing information between platforms need to be developed, along with mechanisms for meta-level search and retrieval access across all platforms.
b. Mechanisms for managing, sharing and creating a two-way flow of community information need to be encouraged. The Community Knowledge Workers project described in Chapter 3 is one example of this, in which farmers receive value-added information through intermediaries. Community knowledge workers generate and send information through their mobile phones to a central location where it is analysed, enhanced and then redistributed for community use. This project is a strong candidate for wider replication.

Rationale:

ICT applications, in particular Web-based platforms, can play a significant part in supporting adaptation planning and implementation which responds to local circumstances and capacity.

In planning for adaptation, it is crucial to increase planners' awareness and knowledge of whether and how projected changes will have an impact on government programs, communities, systems and enterprises so that they are better able and more prepared to revise their management decisions and

practices. Initial successes with Web based adaptation platforms have proved promising in supporting the exchange of research and experience among experts and practitioners. Based on the case studies in Chapter 4, however, it would appear that current platforms may be targeting a small subsector of African society, rather than having broad based impact. Hubs that focus at a continent-wide or regional level may not be serving immediate information needs at the national level, suggesting that the development of national adaptation hubs would be appropriate. This is reminiscent of the concept of country gateways in the World Bank's original Development Gateway [now Zunia] project, although the development of hubs need not be so elaborate or costly as it was in that case.
Capacity-building for engagement in virtual communities may also be valuable at the local level (community based organizations, village councils, *etc*.) if the tools deployed are appropriate for specific communication needs and for the meaningful exchange of adaptation information. For example, they should make use of all communication resources available, including radio and mobile phones as well as the internet.

Planners of adaptation projects in Africa should consider how to connect local community stakeholders to researchers, planners and policy makers using Web-based platforms such as AfricaAdapt. There is an opportunity for the designers of such platforms to consider how to reach out to custodians of traditional knowledge especially that concerned with agricultural practices such as terracing, pasture rotation and contour farming. Systematically gathering knowledge and information across communities, nations, regions and the continent would be a significant step in expanding access to tacit knowledge on practices that have proved successful.

In exploring this potential for ICT programming, however, it should be borne in mind that participants need to have practical reasons or incentives to exchange information - that participating and sharing knowledge should add value from their point of view. Learning from knowledge exchange requires motivated individuals and facilitation in order for it to be successful.

In general, much larger ICT-enabled collaborative networks are needed for the provision of appropriate and useful knowledge that will help to facilitate adaptation to climate change. In the Community Knowledge Workers (CKW) project in Uganda (described in chapter 4), a network consists of partners who analyze information received from meteorological stations and then disseminate relevant adaptation messages to target recipients. Other institutions that have the expertise and knowledge to generate information in specific sectors are also part of this network. There is an opportunity for these networks, focused on adaptation-related information, to establish linkages with established networks for early warning and disaster prevention and for the reduction of disaster impacts.

Feedback loops with these kinds of systems are important. In Uganda, workshop participants were able to critique the relevance of agricultural information received by SMS when provided with the opportunity to do so. Feedback on the accuracy and applicability of information, its use and relevance is needed if systems are to become more reliable, increase its usage base, and to improve in quality.

This study also suggests an opportunity for crowd sourcing based on user-generated data and social application developments (described in the Ushahidi example in Chapter 3). The method of verification and authentication of such data needs to be clearly defined but the opportunity exists for local, low-level, real-time data to be generated more quickly by crowdsourcing than in other ways. Crowdsourcing approaches may provide more relevant and locally contextualized information because catastrophic weather events such as landslides and flash floods are hard to predict – weather stations are designed to provide projections rather than immediate risk data. There is also scope to crowdsource observations on the progress of drought, outbreaks of disease *etc.* Mobile phones used in this way could therefore foster the distribution of up-to-the-minute localized information which could be of real value in immediate, reactive adaptation.

Social innovation practices (such as the random hackaton examples in Chapter 3) combined with crowdsourcing of data present an opportunity for a pragmatic approach to community-based problem solving that is homogenous and bottom-up. Local developers and experts could collaborate to address challenges by generating local data along with the platforms that are needed for decision making. There is a need for an incentive model for developers and experts; and the involvement of the private sector.

5.3 Final Observations

1. **Understanding the local context, both in terms of social/cultural factors and in terms of the local ecosystem**

   When considering options for the replicability of tools discussed in this report, or their scaling up, attention must be given to the adaptation context. The fact that an application or tool worked or is perceived to have worked in one country or region does not imply that it will necessarily produce the same results in another country or region, especially given that the underlying vulnerabilities and risks for climate impacts may vary considerably between the two locations. Indeed, there is a risk that a tool which has been successful in one context might actually do harm in another if inappropriately applied. All tools and information must be adapted for use in the country or local area concerned, especially in countries where there are extremes in weather patterns and events and/or widely varying livelihood opportunities. Community structures, sources of income and the health of the surrounding ecosystem are among factors that should be taken into account.

   It should always be remembered that is not necessary for an initiative to include ICTs for it to be worthwhile or appropriate for adaptation. As indicated above, it is adaptation themes and requirements that should drive decision-making, rather than technology. Policymakers should judge the most appropriate mechanisms for implementation on their likely outcomes, based on real circumstances, rather than relying on overenthusiastic assessments of the potential which ICTs might have in ideal circumstances. Many different factors affect this equation, including

environmental, economic and social contexts, levels of human skill and experience and behavioural norms.

2. **The telecommunications and internet infrastructures need further strengthening across Africa**
   This report has discussed, among other areas of activity, the potential of ICTs in adaptation planning and decision making systems, sensor networks, emergency response mechanisms, information collection and information dissemination. These and other ICT applications which can be deployed in support of adaptation are fundamentally dependent on the availability and quality of communications infrastructure and services including, in many cases, the internet.

   Until ten to fifteen years ago, governments were at the forefront of providing information and communications infrastructure in the large majority of African countries. In recent times however, through deregulation, public-private partnerships and private sector direct investment, the private sector has played the leading role, investing in new undersea cables connect coastal countries to global communications networks, and in extensive domestic using both terrestrial and wireless infrastructure. Government and private sector participants are both engaged in laying inland fibre backbones. Governments have continued to regulate the telecommunications sector, and through universal service requirements and other policies, have encouraged private sector providers to extend access to rural and remote areas, although the principal driver for the extension of infrastructure in rural areas has been that commercial operating companies have sought to increase returns on investment by expanding markets.

   Opportunities for widespread access to broadband and other services continue to improve although there is still a long way to go. While some information can be gathered and disseminated using narrowband networks, broadband infrastructure makes it possible to collect and distribute information that could aid adaptation much more effectively. In some cases, technical capacity and training need to be improved to enable such services.

   Smart systems, sensor networks and other ICT applications that connect the natural and built environments for the purposes of real time management information flows will require significant increases in IP addressing space, beyond that which is available to Africa under Internet Protocol version 4 (IPv4). Investment in the transition to IPv6 will therefore play a part in maximizing the value of ICT networks for adaptation.

3. **The role of ICTs in supporting public outreach and awareness on climate change and adaptation.**
   The final area of importance to be considered here is the role which ICTs can play in supporting wider public outreach and awareness campaigns – helping citizens to understand the underlying causes of the changes that may be affecting them, and encouraging positive and adaptive behaviour changes. Reference was made in the UN Framework Convention on Climate Change (Article 6) and in the Kyoto Protocol (Article 10), for the development of education, training and public awareness raising strategies as essential implementation mechanisms for adaptation. In 2002, governments

also agreed to the five-year New Delhi work programme on Article 6 of the Convention (Decision 11/CP.8), extending that mandate for a further five years (Decision 9/CP.13). They anticipated that this shared commitment to education and communications would lead to enhanced "cooperation, coordination and exchange of information among governments, intergovernmental organizations, non-governmental organizations and community-based organizations, as well as the private and public sectors."[388]

The linkages between ICTs and climate change adaptation have only begun to be explored in depth in the last two to three years. There has, in particular, been only limited research to date on whether and how climate change education and communications strategies have been implemented, particularly at the local level and particularly in developing countries, and concerning what the outcomes of those strategies have been: what works, what does not, what needs to be done next. Further research urgently needs to be undertaken in this area. This should take into account the more substantial work which has been done on the linkages between ICTs and other policy and development domains, including health, agriculture and education, which are reviewed in other studies for the Transformation-Ready programme.

[388] UNFCCC, Retrieved: www.unfccc.int/cop8/latest/14_cpl3_sbstal23add1.pdf