CLIMATE CHANGE VULNERABILITY AND INFRASTRUCTURE INVESTMENT

ASSESSMENT AND ANALYSIS FOR SMALL SCALE WATER UTILITIES IN THE LAKE VICTORIA BASIN

Guide Book for water and wastewater utilities

Authors: Mike Rabe & Guy Price

UN-HABITAT FOR A BETTER URBAN FUTURE

Re-Solve Consulting (Pty) Ltd

ALLIANCE TO SAVE ENERGY Creating an Energy-Efficient World

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1 FOREWORD

Scientific studies completed in the last three decades prove unequivocally that the climate of planet earth is changing. This change which manifests itself mainly in the form of increasing surface temperatures can be attributed to anthropogenic – or human – activity associated with greenhouse gas emissions and specifically CO_2, mainly as a result of the combustion of fossil fuels such as coal and oil.

Additionally, recent studies have shown that the rate of warming is accelerating and that the first decade of this century was hotter than the 1990's, at the time the hottest decade on record. Even if the release of CO_2 emissions into the atmosphere was drastically reduced or halted today through effective mitigation measures, global temperatures will continue to rise for another 50 years due to emissions already accumulated in the atmosphere and the slow rate of absorption of these gases back into the natural environment.

Global climate change will give rise to increased surface temperatures, altered rainfall patterns including increased precipitation for many regions and pronounced drought in others, increased intensity of storm events such as tropical cyclones, hurricanes, and thunderstorms, as well as rising sea levels.

The effect of these changes on the built urban environment, especially installed infrastructure for the delivery of essential services, will be particularly severe and even more so for developing countries where resources to deal with anticipated impacts are lacking. Because the delivery of wet services is dependent on water resources and tends to be an energy intensive operation, water and wastewater utilities will be most vulnerable to the impacts of climate change.

It is therefore imperative that the providers of these services embark on a programme of proactively ***adapting*** to the impacts of climate change and ***mitigating*** greenhouse gas emissions through improved pumping efficiencies. Because adaptation can take on many forms, utilities must apply logic and rational thinking to this process and prioritize interventions that are most likely to cost effectively address identified impacts.

Furthermore, because investments made in infrastructure are long term by nature, it is critical that the provision of *future infrastructure* be given careful consideration to ensure resilience against climate change impacts.

Successful adaptation to and mitigation of climate change is a function of managerial capacity at national, regional and local level. This Guidebook and accompanying material has been developed as a *management tool* to assist you the water service authority/provider in formulating a **climate change adaptation and mitigation plan**. It is intended to offer a pragmatic approach and process that can be completed by a representative climate change team without the need for external specialist support.

As you address identified vulnerabilities to climate change and become more resilient to its impacts, your community will benefit from improved service delivery, improved water quality and quantity, consistent water supply, greater efficiency, extended service provision, as well as improved health and hygiene.

Robert Goodwin

UN Habitat

2 INTRODUCTION

As a water or wastewater utility manager, you are facing unprecedented challenges that include:

- Demographic shifts and population increases
- Ever increasing regulatory requirements
- Maintenance and replacement of dilapidated and ageing infrastructure
- Increased security concerns
- Increased costs especially energy costs associated with service delivery
- Increased complexities relating to the management of personnel and budgets
- Disjointed decision making processes

In addition, now and increasingly so in the future, your utility will also need to deal with the impacts of climate change. Although you may consider these as insignificant when compared to some of other pressing short-term reactive type issues, you will likely find that existing climate related issues such as flooding, water scarcity, and storm water management will be exacerbated by relatively moderate changes to climatic conditions.

Your utility may also be significantly exposed to climate change impacts that occur elsewhere in the world or in neighbouring countries, in particular with respect to food and water security and human migration driven by regional and local climate change. Indeed many refugee crises currently being experienced around the globe are being driven by climate related food and water insecurities.

> **"Climate change will affect all societies and ecosystems most profoundly through the medium of water...An integrated set of policies for water management at every level of government is critical to the economic, social and environmental wellbeing of societies everywhere."**
>
> **Zafar Adeel, Chair of UN Water**

Dealing with these challenges will require utilities to better manage staff, resources, and installed infrastructure as well as develop programs and systems that adapt to the reality of Climate Change and are integrated into the current planning and operating environment.

The purpose of the ***Climate Change Vulnerability and Assessment Guidebook for Small-scale Utilities*** is to assist you in completing a climate change adaptation and mitigation plan for your utility that includes:

- An assessment of potential risks to operations as a result of CC,
- Conceptualized adaptation and mitigation measures to counteract the impact of CC,
- Set targets to be achieved during and after implementation,
- Prioritized adaptation and mitigation measures, and
- Monitored and evaluated outcomes of implemented measures.

The steps outlined in this guidebook are replicable and represent an iterative process. They will also assist you in:

I. *Identifying CC objectives and targets;*
II. *Identifying and prioritizing critical operations;*
III. *Identifying 'low cost' and 'no cost' efficiency interventions;*

IV. *Benchmarking your CC adaptation performance;*

V. *Defining appropriate performance indicators to use in measuring progress towards the proofing of operations against CC;*

VI. *Documenting and communicating success; and*

VII. *Reviewing progress and making the necessary adjustments.*

Not only does the completion of such a process make sound business and environmental sense to your utility, but it will also greatly assist you in adopting a systematic management approach to dealing with some of the other challenges highlighted above, as well as better understanding critical aspects of operations. This process should not be seen or implemented *in isolation* to other processes, but should in fact be *integrated into existing strategic planning and decision-making processes*.

In addition successful completion of a climate change adaptation and mitigation process will also improve confidence by the public in your ability to deliver water and sanitation services, thus promoting a healthier relationship between you and your customers.

Various tools and resources are available to assist you as a utility manager in undertaking the outlined process. This ***guidebook*** will define and link you to those resources and help you to align your adaptation and mitigation plan to current infrastructure investment and operational plans.

Step-by-step sessions, modules and exercises are provided in this guidebook together with objectives, defined concepts and examples to assist you in completing your plan.

This guidebook has been drafted in collaboration with larger and smaller water and sanitation utilities and hence you will find it relevant to your situation.

3 DEFINITIONS

Below is a list of definitions used in this guidebook. Most of the definitions relating specifically to climate change have been sourced and adapted from *Climate Adaptation: Risk, uncertainty and decision-making. UKCIP, 2003.*

Adaptation – Adaptation is a process by which strategies to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed and implemented. This can include strategies to increase the resilience of systems, such as reducing pollution and pests for natural ecosystems. See also *climate adaptation*.

Adaptation plans – Development of a framework setting out key risks with associated actions for adaptation.

Adaptive capacity – The ability of a natural or human system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes in climate conditions.

Climate – Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description of the climate system.

Climate adaptation – The building of climate change resilience. Adaptation is a process whereby individuals and communities seek to respond to 'actual or expected climatic stimuli and resulting effects'. The process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits, associated with climate variability and climate change. See also mitigation.

Climate change – A change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. The United Nations Framework Convention on Climate Change (UNFCC) defines climate change as a change of climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period, thus making a distinction between climate change attributable to human activities and climate variability attributable to natural causes.

Climate change (CC) programme manager – The person assigned responsibility and management authority to implement a climate change adaptation and mitigation plan.

Climate change scenarios – A coherent and internally-consistent description of the change in climate by a certain time in the future, using a specific modelling technique and under specific assumptions about the growth of greenhouse gas and other emissions and about other factors that may influence climate in the future.

Climate change projection – Projections are sets of future conditions, or consequences, based on explicit assumptions. Climate change projections estimate the response of the climate system to scenarios, often based upon simulations by climate models. Projections are therefore subject to substantial uncertainty.

Communicable diseases – Illnesses caused by micro-organisms and transmitted from an infected person or animal to another person or animal.

Downscaling – Refers to techniques that enable the results of global climate models (GCM's) to be made relevant to local decision-makers and impact assessment. Downscaling techniques generally involve statistical methods of data interpolation, multivariate regression, weather circulation typing, and weather generators.

Global Climate Model (GCM) – Computer models designed to help understand and simulate global and regional climate, in particular the climatic response to changing concentrations of greenhouse gases. GCM's aim to include mathematical descriptions of important physical and chemical processes governing climate, including the role of the atmosphere, land, oceans, as well as biological processes. The ability to simulate sub-regional climate is determined by the resolution of the model.

Greenhouse gases – A number of anthropologically produced and naturally occurring gases whose presence in the atmosphere traps energy radiated by the Earth. Carbon dioxide (CO_2) is the most important and commonly discussed greenhouse gas, although also included are water vapour (H_2O), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3). Other entirely human-made greenhouse gases in the atmosphere include halocarbons and other chlorine and bromine containing substances.

Impact – A beneficial or in most cases, detrimental consequence.

IPCC – The Intergovernmental Panel on Climate Change (IPCC) was jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to assess the scientific, technical and socio-economic information relevant for the understanding of the risk of human-induced climate change.

IPCC Scenarios – Due to the fact that the future is uncertain it is not possible to predict climate change with any level of accuracy. Therefore the IPCC developed scenarios to cover a range of the driving forces of future green-house gas emissions, from demographic development, socio-economic development to technological change and economic developments.

Mitigation – In the context of risk management, mitigation refers to any action to reduce the probability and magnitude of unwanted consequences. Hence, adapting to climate change is a strategy undertaken to mitigate the risks associated with future changes in climate. There is scope for confusion in using this term since mitigation, as used in climate change policy, typically refers to the reduction in greenhouse gas emissions (as in climate change mitigation), which is a specific example of risk management.

Resilience – The ability of a human or natural system to recover from the effect of an extreme load that may have caused harm.

Risk – A situation, or characteristic of a system in which the probabilities that certain states or events will occur (or have occurred in the past) are precisely known. Risk is a combination of the chance or probability of an event occurring, and the impact or consequence of the event, given that it has occurred.

Stakeholder – People, including organisations, who have an investment, financial or otherwise, in the consequences of any decisions taken.

Urbanization – The physical growth of urban areas resulting from the migration of the population from rural areas into existing urban areas. Effects include change in density, impact on infrastructure and administration services.

Vulnerability – The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity[1]. It can also refer to the magnitude of harm that would result from a particular hazardous event.

Water Conservation – The minimization of loss or waste; care and protection of water resources and the efficient and effective use of water.

Water Demand Management – The adaptation and implementation of a strategy by a water institution or consumer to influence the water demand and usage of water in order to meet any of the following objectives: economic efficiency; social development; social equity; environmental protection; sustainability of water supply and services and political acceptability.

Water Efficiency – Improved technologies and practices that deliver equal or better service while using less water.

Water Security – The reliable availability, acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risk.

[1] Definition by the IPCC http//www.ipcc.ch/pub/syrgloss.pdf

4 ABBREVIATIONS/ ACRONYMS

The following is a list of commonly used acronyms associated with water and sanitation utilities as well as climate change.

AOGCM	Atmospheric-Ocean General Circulation Model
CAPEX	Capital Expenditure
CC	Climate Change
CCAF	Climate Change Adaptation Framework
CCS	Carbon Capture and Storage technology
CDM	Clean Development Mechanism
CER's	Certified Emission Reductions
CMA	Catchment Management Agency
DMA's	District Management Areas
DMP	Disaster Management Plan
EE	Energy Efficiency
ERP	Emergency Response Plan
GCM's	Global Circulation Models
GHG's	Greenhouse Gases
NWA	National Water Authority
IFI's	International Finance Institutions
IPCC	Intergovernmental Panel for Climate Change
IRM	Integrated Resource Management
IRP	Integrated Resource Planning
IUWM	Integrated Urban Water Management
IWA	International Water Association
IWRM	Integrated Water Resource Management
Kℓ	Kilolitre
KPI	Key Performance Indicator
LBNL	Lawrence Berkeley National Laboratory
LG	Local Government
LV	Lake Victoria
Mℓ	Megalitre
M&E	Monitoring and Evaluation
MNF	Minimum Night Flows
MWE	Ministry of Water and Environment (Uganda)

NEMA	National Environmental Management Act
NRW	Non-Revenue Water
NGO	Non Governmental Organization
NWA	National Water Act
NWRS	National Water Resources Strategy
NWSA	National Water Services Act
NWSC	National Water and Sanitation Corporation
O&M	Operations and Maintenance
OPEX	Operational Expenditure
PRA	Preliminary Readiness Assessment
PRV	Pressure Reducing Valves
RE	Renewable Energy
SCADA	Supervisory Control and Data Acquisition system
SEI	Stockholm Environmental Institute
SPV	Special Purpose Vehicle
UAW	Unaccounted for water
UN Habitat	United Nations Human Settlement Programme
UNFCCC	United Nations Framework Convention on Climate Change
VER’s	Verified Emission Reductions
WatSan	Acronym for Water and Wastewater
WC	Water Conservation
WC/WDM	Water Conservation and Water Demand Management
WDM	Water Demand Management
WEAP	Water Evaluation and Planning System
WED	Water Efficient Device
WELS	Water Efficiency Labelling Standards
WHO	World Health Organisation
WSA	Water Services Authorities
WSB	Water Services Board
WSDP	Water Services Development Plan
WSP	Water Services Provider
WSRB	Water Service Regulatory Board
WSI	Water Services Institutions
WSU	Water and Sanitation Utility

5 ACKNOWLEDGEMENTS

The success of an initiative such as this is largely dependent on the support and commitment of the organisations and people driving the project as well as those who are the beneficiaries. On behalf of the study team, the authors would like to thank the following individuals and organisations who have contributed to this project.

Participating Organisations

National Water & Sewerage Corporation – Uganda

Bukoba Urban Water and Sewerage Authority (BUWASA) – Tanzania

Ministry or Water and Irrigation - Tanzania

Gusii Water & Sanitation Company – Kenya

National Water & Sewerage Corporation, Masaka Area - Uganda

Lake Victoria South Water Services Board - Kenya

Project Head (Funding Organisation)

Robert Goodwin - Chief, Lake Victoria - Section Water, Sanitation and Infrastructure Branch UN-HABITAT

Project Team

Laura Van Wie McGrory – Director, International Programs, Alliance to Save Energy

Arlene Fetizanan - Program Manager, International Alliance to Save Energy

Omar Aslam, MPP - Lawrence Berkeley National Laboratory & University of California, Berkeley

Larry Dale, Phd - Lawrence Berkeley National Laboratory & University of California, Berkeley

Vishal Mehta, Phd - Stockholm Environmental Institute – U.S. Center

David R. Purkey, Phd - Stockholm Environment Institute – U.S. Center

Norman L. Miller, Phd - Lawrence Berkeley National Laboratory & University of California, Berkeley

Nicole J. Schlegal – Lawrence Berkeley National Laboratory & University of California, Berkeley

Julia Friedlander, Michelle Neukirchen, Eric Seilo, Michael Tran - University of Johns Hopkins Paul H. Nitze School of Advanced International Studies

George Krhoda, Phd - Climate XL, Associate Professor of Geography, University of Nairobi

Kenneth Odero – Climate XL, Kenya

Dugald Ross – Re-Solve Consulting (Pty) Ltd, South Africa

6 THE SCIENCE OF GLOBAL CLIMATE CHANGE

It is important for the user of this guidebook to have a high level understanding of climate change and the basic concepts related to same, especially in terms of the links between water as a resource, climate change and utility operations. An overview of the science of climate change is therefore presented below. Definitions of the most important terms and concepts presented in this section have been included in the definition section above (Section 3).

6.1 INTRODUCTION TO CLIMATE CHANGE

Greenhouse gases (GHG's) such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) exist naturally in our atmosphere. These gases trap energy from the sun and keep the climate of the Earth from freezing. Without them, life would probably not exist – certainly not life as we know it. Our activities though, especially the burning of fossil fuels (in power plants, automobiles, and boilers), waste disposal and energy resource development, industrial operations, use of chemicals in agriculture, land use change, practices and deforestation, are raising the concentrations of these gases in the atmosphere.

Higher concentrations of these gases in the atmosphere are effectively 'trapping' heat due to the greenhouse gas effect, and thus increasing global surface temperatures. Since the 1900's global temperatures have already increased by almost 1°C (1°F). In fact, the 1990's appears to be the hottest decade of the last millennium. Recent reports indicate that the first decade of the 21st century was hotter than the 1990's. Temperatures are projected to rise another 1.5 to 6°C by the end of this century. Although this rise may not seem like much, studies have shown that the temperature was only 5°C colder during the last Ice Age which covered much of the Northern Hemisphere in a thick sheet of ice!

With increasing surface temperatures the following global 'climate change impacts' are already being experienced and/or will become more pronounced in the future:

- Rise in global sea levels. The sea level is projected to rise between 0.1 and 1.0 meter by 2100, with approximately 0.5 meter being the best estimate.
- Rise in global precipitation (with changes in where precipitation falls).
- Greater variation in weather patterns resulting in greater intensity of storm events, droughts, etc.

At a regional level, from a sub-continental scale down to the country, province or village, climate variability will probably increase, although the impacts are more uncertain. The following general projections apply:

- Temperatures are projected to rise for virtually all land areas.
- There will be *more* warming at higher latitudes than lower latitudes with warming even expected in the tropics. Inland areas will tend to warm more than coastal areas.
- Regional precipitation patterns will change, with some areas experiencing less precipitation and others more. Generally the very high latitudes and equatorial regions are expected to see increases in precipitation.
- Many areas and particularly the mid- and high-latitude regions may see an increase in intense precipitation events with the amount of rain falling during intense storm events increasing.
- The potential for drought will increase. Dry periods will likely become drier. Higher temperatures translate into higher evaporation rates, resulting in soils drying out faster and thus increasing the potential for drought.
- The intensity of tropical cyclones is likely to increase as sea surface temperatures increase due to higher air temperatures. More intense tropical cyclones have higher wind speeds and more

precipitation.

- The intensity of rain and snow storms will likely increase as higher temperatures intensify atmospheric circulation patterns.

Developing countries appear to be more vulnerable to the impacts of climate change. This coupled with a limited resource base from which to operate will make management of climate change even more challenging. Although most development planning takes into account population growth, migration, and socioeconomic changes, little attention is paid to potential changes in local and regional climatic conditions that could take place over the next 50 years.

This g***uidebook*** has been designed to offer a pragmatic approach to smaller utilities in assessing vulnerabilities and impacts to climate change and formulating a workable adaptation and mitigation plan to build much needed CC resilience going forward.

More detailed discussions on the science of climate change can be found in reports issued by the Intergovernmental Panel on Climate Change (IPCC) available in PDF version on the IPCC website at http://www.ipcc.ch/pub/spm22-01.pdf.

6.2 IPCC STUDIES, REPORTS AND UN RESPONSE

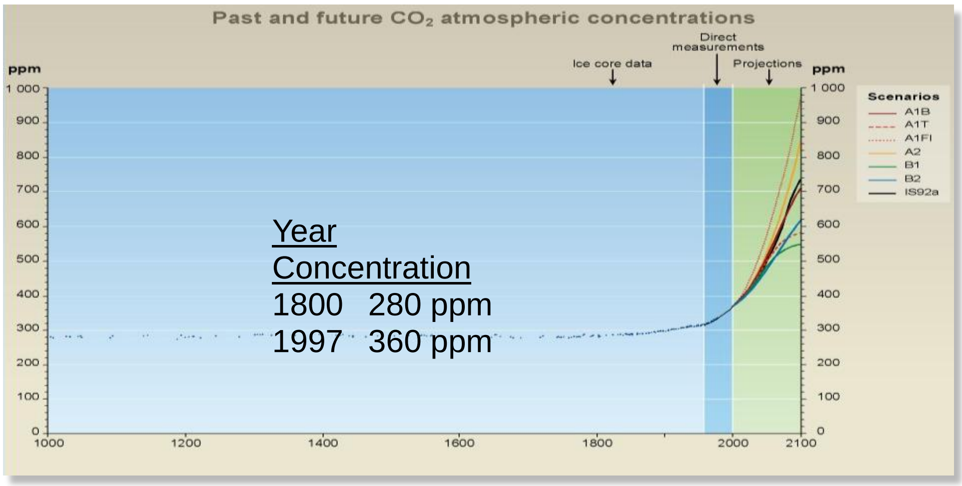
The Intergovernmental Panel on Climate Change (IPCC) was founded by the United Nations in 1988. It consists of leading scientists who study climate change and produce three reports every five to seven years. These summarize what is known about the science of climate change, such as how much the climate may change, how climates will change in various regions, what the impacts of climate change will be and what response measures should be implemented.

In its Fourth Assessment report published in 2007, the IPCC concluded that:

- Warming of the climate system is unequivocal.
- More than 50% of the observed increase in globally averaged temperatures since the mid-20th century is very likely (confidence level >90%) due to the observed increase in anthropogenic (human) GHG concentrations.
- Hotter temperatures and rises in sea level “would continue for centuries” even if GHG levels are stabilized, although the likely amount of temperature and sea level rise varies greatly depending on the fossil intensity of human activity during the next century.
- The probability that this is caused by natural climatic processes alone is less than 5%.
- Global atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values over the last 650,000 years.

The graph below, published by the IPCC graphically illustrates how CO_2 levels are changing over time…

Figure 6-1: Change in CO_2 concentrations



Framework Convention on Climate Change

In response to global climate change, the United Nations drafted an international treaty called the "**United Nations Framework Convention on Climate Change** (UNFCCC), which was adopted and ratified at the "Rio" conference in 1992. This convention came into effect on 21 March 1994. There are currently 194 parties to this agreement.

Signatory governments agreed to:

- Gather and share information on GHG emissions, national policies and best practices for reducing them,
- Launch national strategies for addressing GHG emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries,
- Cooperate in preparing for adaptation to the impacts of climate change.

> **"The systematic destruction of the Earth's natural and nature based resources has reached a point where the economic viability of economies is being challenged - and where the bill we hand to our children may prove impossible to pay"**
>
> **Achim Steiner, Executive Director of UNEP**

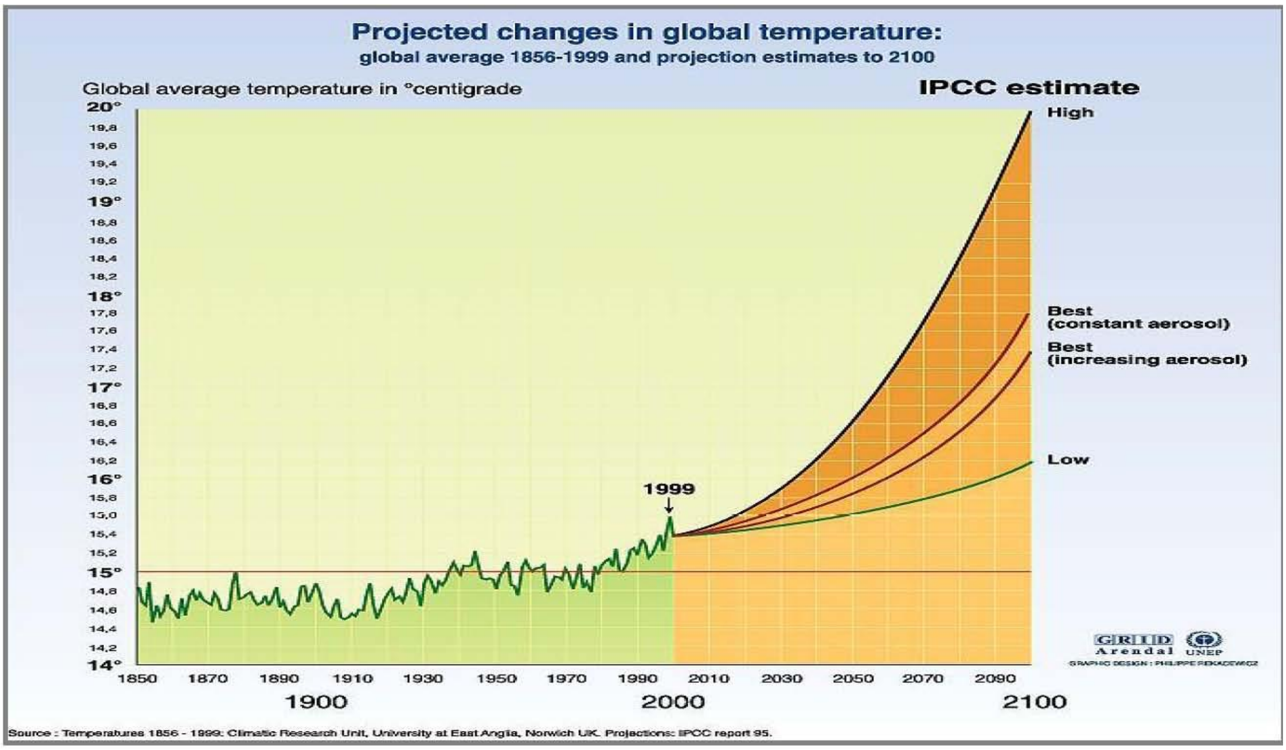
The Kyoto Protocol

An addition to the treaty, the **Kyoto Protocol** was adopted in 1997 by 37 industrialized countries and the European Community, committing the signatories to reducing greenhouse gas emissions to below 1990 levels through:

- Emissions trading (the "carbon market")
- Clean development mechanism (CDM)
- Joint implementation (JI)

Through this protocol, various opportunities exist for developing countries to access funds and assistance to address especially climate change adaptation concerns.

The following graph represents the projected rise in surface temperatures as a result of global warming:


Projected changes in global temperature:
global average 1856-1999 and projection estimates to 2100
Global average temperature in °centigrade
IPCC estimate
High
Best
(constant aerosol)
Best
(increasing aerosol)
Low
1999
20°
19°
18°
17°
16°
15°
14°
1850
1870
1890
1910
1930
1950
1970
1990
2010
2030
2050
2070
2090
1900
2000
2100
Source : Temperatures 1856 - 1999: Climatic Research Unit, University at East Anglia, Norwich UK. Projections: IPCC report 95.

6.3 MITIGATION, SEQUESTRATION AND ADAPTATION

Responses to global warming resulting from the emission of GHG's are grouped into three broadly defined categories, namely **Mitigation**, **Sequestration** and **Adaptation**. Each of these is briefly discussed below.

Mitigation involves

- Reducing emissions of CO_2 through:
  - Fuel switching
  - Renewable energy
  - Energy efficiency
  - Energy conservation
- Reduced emissions of methane

Sequestration involves

- Increasing the natural uptake of CO_2 through improved land-use management relating to:
  - Agriculture
  - Development
  - Forest management
- Using a technology called carbon capture and storage (CCS), trapping carbon dioxide emissions produced by large power plants, and storing them in a way that prevents them from entering the earth's atmosphere.

Adaptation involves

- "Climate proofing", i.e., increasingly ensuring the development of climate resilient systems and societies.

Most policy, action and debate on climate change to date has been concerned with mitigation, that is to say, limiting the severity of the long term consequences of climate change by *reducing greenhouse gas emissions*.

Although adaptation is often seen as secondary to mitigation, regardless of what mitigating actions are taken from this point onwards, climate change *in the future* is inevitable because of emissions that have already occurred since the beginning of the industrial revolution. Although Greenhouse Gases are absorbed back into natural ecosystems and the environment, this is a slow process which could take many years before the balance is restored.

The 4th IPCC Assessment Report highlighted that impacts and risks of climate change ***are more imminent and severe than previously thought*** and between 2050 and 2100 climate change could have a disastrous impact on economies, society, security, development and social safety net systems, particularly in poor countries.

Notwithstanding the need for any country, community, society, or water service provider to consider their potential vulnerability to climate change and adopt appropriate mitigation measures, the main response of especially utilities to climate change should be the building of resilience through the implementation of sensible adaptation measures.

Limited mitigation opportunities linked mainly to the creation of energy efficiencies (EE) in especially pumping operations may present themselves and should be pursued in parallel with adaptation initiatives.

This ***Guidebook*** has been drafted to help you *build* your adaptive capacity, offering a step-by-step guide to assist you with a vulnerability and impact assessment, followed by the documenting and prioritizing of adaptation and mitigation options.

6.4 REGION SPECIFIC STUDIES, FINDINGS AND RECOMMENDATIONS

By applying '**downscaling**' techniques to GCM's, scientists can make predictions related to climate change at a regional and even local level. Although a greater degree of uncertainty is embedded in these predictions, they do provide an indication of changed climatic conditions that can be expected in the longer term.

Regional and local forecasts are critical to understanding variations that may occur in the climate of your region, in turn allowing for an assessment of the vulnerability of your utility's infrastructure and operation to CC, its potential impacts, and hence then the type and nature of adaptive measures that should be implemented to provide the required CC resilience.

As a starting point therefore, it is important to secure any GCM projections that may have been made for your region or locality. These may be available from national educational institutions, research organizations, government departments, commercial/development banks, as well as international organizations such as the UN, the IPCC, and/or regional trading blocs.

An assessment of the larger urban centres for Asia/Pacific, Middle East and Africa is also available in a 2008 report done by Mastercard Worldwide Insight[2].

Lake Victoria Region

Although this guidebook has been drafted as a tool that can assist any WSU in undertaking a CC adaptation and mitigation process, the study area specifically linked to this Guidebook is the Lake Victoria (LV) region (or basin) in East Africa and the Water and Sanitation Programme of UN Habitat linked to this region (LVWATSAN).

A project report relating to **Climate Change Vulnerability and Infrastructure Assessment and Analysis for Small Scale Water Utilities in the Lake Victoria Basin** was completed by Lawrence Berkeley National Laboratories in the U.S.[3], and the remaining portion of this chapter contains relevant excerpts from this same report.

> Globally, the present effects of climate change are captured most dramatically in the findings of an upward trending increase in average global surface temperatures, which have risen by 0.8°C since 1900, and 0.6°C in the past three decades.[4] The IPCC review of overall climate change research found this rise to be unequivocally attributable to human activities, and predicted that if greenhouse gases, one of the leading contributors to climate change, continue to rise in the atmosphere, mean global temperatures will increase between 1.4 and 5.8°C by the end of the 21st century.[5]

[2] Urbanization and Environmental Challenges in Asia/Pacific, Middle East and Africa – Ranking of Worldwide Centers of Commerce.

[3] Climate Change Vulnerability and Infrastructure Assessment and Analysis for Small Scale Water Utilities in the Lake Victoria Basin, 30 July 2010 – *Omar Aslam. Larry Dale, Vishal Mehta, Normal Miller.*

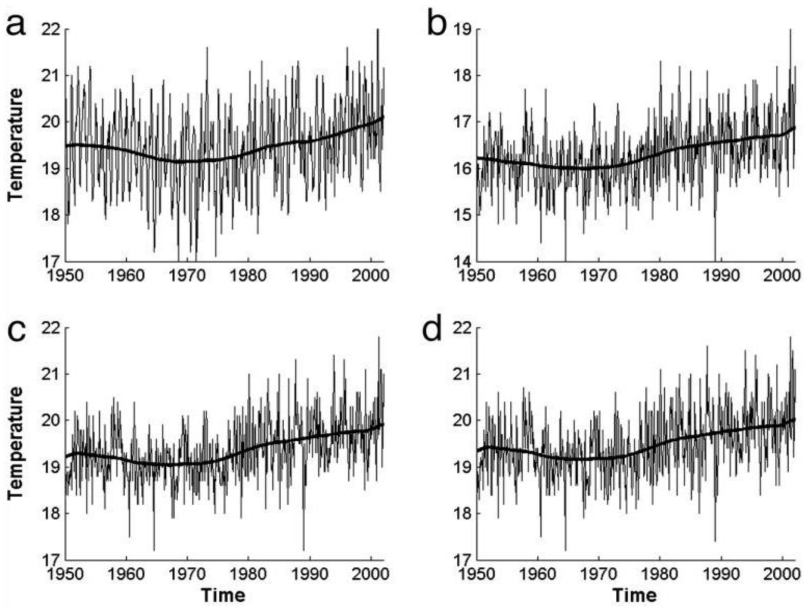
[4] James Hansen, Makiko Sato, Reto Ruedy, Ken Lo, David Lea, & Martin Medina-Elizade, "Global Temperature Change," Proceedings of the National Academy of Sciences, Vol. 103 no. 39, pp. 14288-14293, September 2006.

[5] IPCC, "Climate Change 2007: The Physical Science Basis," *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, IPCC Secretariat, Geneva, Switzerland, 2007.

6.4.1 Historical Climate – East Africa

The highly sensitive natural water balance of Lake Victoria is evident in the historical record. The lake region has experienced many prolonged, multi-year droughts punctuated by episodic floods.[6] Significant long-lasting periods of droughts and overall dry conditions were first recorded in equatorial East Africa in the middle of the 18th Century, and again between 1820 and 1850. Later, from 1870 until about 1895, East Africa received above average rainfall, then from 1895 to 1920 rainfall for this region fell significantly below its 100 year average, creating periods of drought and water stress throughout equatorial Africa. In addition to precipitation, climate change has had a substantial effect on Lake Victoria temperatures. Temperature records for Lake Victoria show an overall increase of one degree Celsius between 1950 to 2006 (Figure 6-2 below).

Figure 6-2: Annual Temperatures Around Lake Victoria – 1950 to 2006



A) Kericho, Kenya; B) Kabale, Uganda; C) Gikongoro, Rwanda;
D) Muhanga, Rwanda. Source: Pasqual et. al. 2006[7]

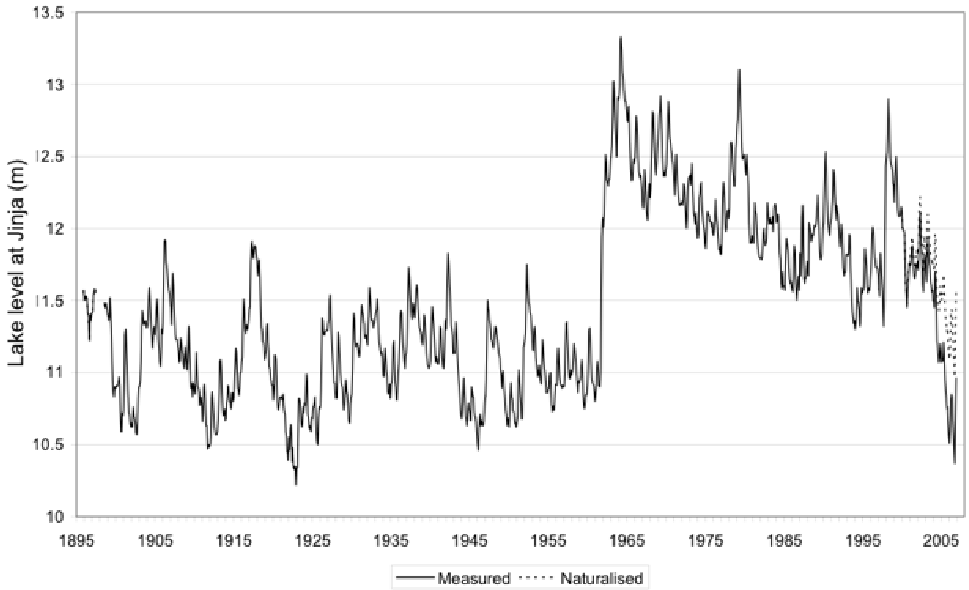
At present, East Africa is characterized by widely diverse climates ranging from desert to forest within a relatively small area. Rainfall seasonality is complex, differing significantly over short distances. The annual cycle of East African rainfall is bimodal, with wet seasons being from March to May, and October to December. The long rains (March to May) contribute more than 70% to the annual rainfall and the short rains less than 20%. However, note that most of the inter-annual rainfall variability comes during the short rains of October to December[8]. Consequently, East Africa climate models are highly focused on the October-December period.

Figure 6-3: Lake Victoria Water Level (Meters) - 1895 to 2005

[6] Nicholson, S.E., 1981: The Historical Climatology of Africa . Climate and History T.M.L. Wigley, M.J. Ingram, G. Farmer, eds., Cambridge Press, 249-270.

[7] M. Pascual, J. A. Ahumada, L. F. Chaves, X. Rodó, and M. Bouma, "Malaria resurgence in the East African highlands: Temperature trends revisited," Proc Natl Acad Sci U S A. 2006 April 11; 103(15): 5829–5834.

[8] S. E. Nicholson, "A Review of Climate Dynamics and Climate Variability in Eastern Africa," *The limnology, climatology and paleoclimatology of the East African lakes* (T.C. Johnson and E. Odada, eds.), Gordon and Breach, Amsterdam , 1996, 25-56.



Source: Nicholson 1998.[9]

6.4.2 Climate Change – East Africa

In equatorial Africa, climate change trends point to an increase in mean temperature and a rise in sea levels throughout this century. In general, the African continent as a whole is likely to warm over the next 100 years, and these warmer temperatures are likely to exceed annual global mean warming over all seasons. Annual rainfall is likely to exceed historical trends in East Africa, although annual rainfall will potentially decrease across the rest of Africa.[10] The aggregate result of 21 climate models for the A1B[11] scenario finds that the predicted temperature increase for East Africa is 3.2°C for the 2080-2099 period. Rainfall is predicted to increase 7%, with extremely rainy conditions predicted to increase by approximately 30%.[12]

Global warming is expected to lead to increased precipitation and evaporation over Lake Victoria as the hydrologic cycle intensifies. This is due in part to the increased capacity for the atmosphere to hold more water vapour, leading to more variability in precipitation. The IPCC 4th *Assessment Report's* Global Climate Model (GCM) simulations indicate a general weakening of atmospheric circulation, with the possibility of an El Nino-like global warming mean state.[13] Evaporation is expected to increase with increasing temperatures, but is complicated by uncertainties in cloudiness over this region. Global Climate Model projections of 21st century precipitation are also uncertain due to the complexity and nonlinearity of precipitation and cloud-radiative processes. The IPCC *4th Assessment Report* gives a

[9] Water levels are based on the station gage in Jinja, Uganda (mouth of Victoria Nile), Nicholson, S. E., and X. Yin, 1998: Variations of African lakes during the last two centuries. In Water resources variability in Africa during the XXth Century, E. Servat, D. Hughes, J.-M;. Fritsch and M. Hulme, eds., IAHS Press,Wallingford, UK, 181-188.

[10] IPCC, 2007.

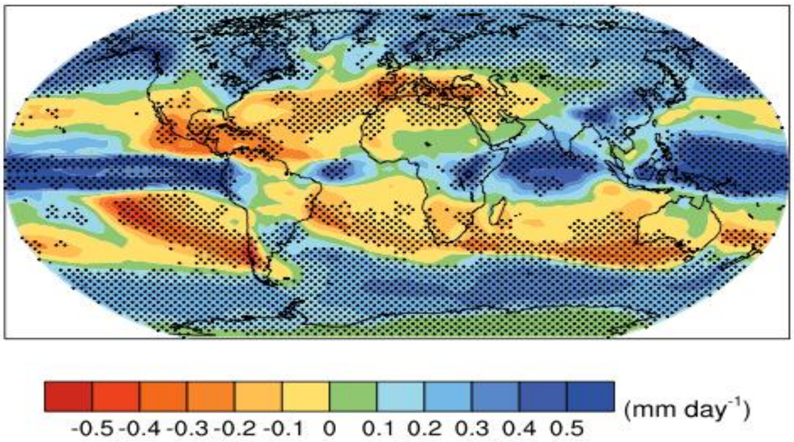
[11] "The A1… scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies…" The B group emphasizes a balance between fossil and non-fossil energy sources. IPCC, "Special Report on Emission Scenarios,"2007.

[12] IPCC, 4th Assessment Report 2007.

[13] Meehl, G.A., and W.M. Washington, 1996: "El Nino-like climate change in a model with increased atmospheric CO2 concentrations," Nature, 382, 56--60.

greater than 66 percent likelihood that equatorial regions will become wetter (Figure 3) with changes in the frequency of wet and dry periods.

Figure 6-4: IPCC 4th Assessment Report on Rainfall from Global Climate Change (2080 to 2099)



Source: IPCC 4th Assessment Report on Global Climate Change. Note: SRES A1B Lake Victoria Basin will have more extreme precipitation. Stippled regions indicate that 85% of the IPCC GCMs are in agreement.

For the countries surrounding Lake Victoria, the regional impacts of global climate change will likely emerge from the interplay of two important factors over the next 50 to 100 years: increased rainfall variability (deviation from the mean), and warmer temperatures. Too much or too little rainfall increases the risk of droughts and floods; such variability in rainfall patterns hinders agricultural planning in regions such as those around Lake Victoria that are almost exclusively dependent on rain-fed agriculture. Additionally, the potential overlap of droughts with increased temperatures will accelerate evaporation in a region where rainfall is responsible for approximately 84% of the Lake Victoria Basin water level.[14]

The Global Climate Simulation Model known as "CCSM" includes regional projections showing an increasing trend in precipitation and temperature response compared to historical climate. The CCSM precipitation projections were built from monthly perturbation factors for maximum and minimum temperature and rainfall, comparing CCSM projections in three 30-year time periods (2010-2039, 2040-2069, and 2070-2099) to the CCSM output for 1971-2000 (

[14] J. V. Sutcliffe and G. Petersen, "Lake Victoria: derivation of a corrected natural water level series," *Hydrological Sciences Journal*, Vol. 52, No. 6, December 2007, pages 1316 – 1321, 2007.

Table 6-1).

Table 6-1: Mean (Monthly) Annual Precipitation Climatologies (Millimeters) for CCSM Global Climate Model and East Anglia Climate Research Unit Lake Victoria Shore Observations

	CRU Stations (Adjusted Historical: 1970 - 1999)	CCSM (1970-1999)	CCSM (2030-2059)	CCSM (2070-2099)
Jan	219.5	208.3	243.1	266.3
Feb	187.5	179.9	203.8	220
Mar	201.2	240.5	244.9	262.5
Apr	196.4	211.2	219	225.5
May	36.8	80.8	85.4	111.5
Jun	0	14.1	18.9	31.1
Jul	0	10.9	13.6	22.6
Aug	0	17.4	34.1	60
Sep	0.8	71.7	109.1	143.8
Oct	32.5	191.9	238.4	242.7
Nov	154.6	255.2	310.2	316.3
Dec	239.3	255.2	321.8	330.2
Annual	1268.5	1737.1	2042.3	2232.6

Source: Miller, 2010.[15]

Simulating precipitation over Lake Victoria within an Atmospheric-Ocean General Circulation Model (AOGCM) hinges on the model's ability to simulate local convective precipitation, the Indian Monsoon circulation, the Inter-tropical Convergence Zone (ITCZ), and tropical Pacific Sea Surface Temperature (SST) variations. There remain numerous systematic uncertainties in the ability of AOGCMs to simulate features of the large-scale system. Convective precipitation over the lake is an enhancement that has been fitted and tested with rain gage and satellite data. We have applied this fit to our data with fair representations of the area-averaged AOGCM precipitation.

The significant findings of research conducted for this project are that the Lake Victoria region will be very wet, with periods of intense precipitation interspersed with droughts. This is expected to increase in variability as warming continues and more or less follows the rationale that wet regions will become wetter and dry regions will become drier. Evaporation over the lake will be most significant during the June-July-August dry season. Although climate projections have significant uncertainties, adaptation management is critical for resilient water systems. Preparing for a hotter future with significantly increased evaporation, rainstorms and drought will require active management of reservoirs to adapt to these dynamic conditions.

Lake Victoria water levels have fluctuated drastically both on an annual and a monthly basis due to a combination of meteorological and water management factors since the 1950s. National administrative

[15] Norman L. Miller and Nicole J. Schlegel, "Analysis of Climate Change in the Lake Victoria Region" Unpublished Draft, 2010.

management of Lake Victoria water levels began in 1954 with construction of the Nalubaale hydro-electric dam along the Victoria Nile outlet on the northern shore of Lake Victoria in Uganda. A second hydro-electric dam, Kiiri, was completed in 2002. The two dams have an installed capacity of 300MW.[16] A few years after completion of the Nalubaale dam, Lake Victoria water levels rose and fell drastically on an annual basis. In 1961-1962 heavy rainfall over equatorial Eastern Africa was far above the climatological average, raising the annual Lake Victoria water level by 2.5m. After 1965, rainfall began to gradually decrease, and together with the administrative over-release of water from the Jinja hydroelectric dams, led to the lowest water levels ever recorded for Lake Victoria during the recent drought lasting from 2002-2006.

Corroborating the findings from water station gage data, satellite radar altimeter data shows the Lake Victoria water level in 1998 at approximately one meter above its 10-year average from 1992 to 2001. The rise in annual water level is attributed to high amounts of rainfall in 1997 and 1998 generated by the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD).[17,18] After 1998, the annual rate of decline in the Lake Victoria water level quickened, dropping 1.4 meters below the 1992-2001 average by 2006.[19] Although the water level rose markedly after heavy rainfall again related to ENSO and IOD in late 2006, the water level remained 0.5 meters below the 1992-2001 average by 2008. This dramatic reduction in the Lake Victoria water level between 1998 and 2008 is attributed partly to drought conditions and greater water releases from the Owen Falls hydro-electric dam complex in Uganda.[20]

Concluding Summary

The LV region has a history of drought as well as heavy precipitation. This month alone has seen over 100 people killed and hundreds of thousands displaced due to rain triggered landslides. Climate theory indicates the tropics will become wetter and equatorial East Africa may be much wetter with increased rainfall intensity. Although climate projections have many uncertainties, adaptation management preparing for continued droughts and floods is critical for a resilient water system. Preparing for a future that is hotter with significantly increased evaporation, intense rainstorms and drought, will require a new awareness on hydropower and reservoir management that is in balance with these changing dynamics.

[16] A third hydro-electric dam, the Bujagali Dam, is under construction about 15 miles downstream of the two Jinja dams (Nalubaale & Kiiri). Estimated installed capacity of Bujagali Dam will be 250 MW, and is scheduled to be commissioned in late 2012.

[17] Nicholson SE. "Historical and modern fluctuations of lakes Tanganyika and Rukwa and their relationship to rainfall variability," *Climatic Change*. 1999;41:53–71.

[18] Yin X, Nicholson SE. "Interpreting annual rainfall from the level of Lake Victoria," Journal of Hydrometeorology, 2002;3:406–416.

[19] Marchant R, Mumbi C, Behera S, Yamagata T. "The Indian Ocean dipole – the unsung driver of climatic variability in East Africa," African Journal of Ecology, 2006;45:4–16.

[20] Sutcliffe JV, Petersen G. "Lake Victoria: derivation of a corrected natural water level series," Hydrological Science 2007;52:1316–1321.

7 PLANNING

Critical to the success of any initiative, project or programme, is a *planning phase* in which the *what*, *why*, *when*, *how* and *who* are established. This phase will help your utility tremendously in organizing, understanding, conceptualizing, positioning, scoping and steering climate change activities from this point onwards.

In the section below modules are presented which will help you kick-start the climate change process, provide organizational structure to your programme, and assist you in positioning this initiative within current planning and management protocols.

The Figure 7-1 below provides a graphical representation of the **recommended planning process** to be undertaken by the utility when developing an adaptation and mitigation plan.

Figure 7-1: Step by Step Approach to Planning

7.1 CHARACTERIZE YOUR UTILITY

Module Objective

Help you understand where you are in the process of completing a CC adaptation and mitigation plan and what steps you still need to take.

Overview

By reviewing the table below (**Worksheet # 1**) and understanding what statement best characterizes your utility, you will be able to establish what your focus should be in planning for climate change and what resources are available for you to complete your plan. The Chapters referred to can be found in this guidebook.

Table 7-1: Worksheet # 1: Characterization of your Utility

Worksheet # 1		
Your Utility…	**Then think about…**	**Resources available to you…**
" is continually dealing with crisis management issues and unable to proactively plan ahead"	Developing an infrastructure investment plan for the renewing of ageing infrastructure that also incorporates CC adaptive measures	Compendium of Best Practices in Water Infrastructure Asset Management[21]
"is thinking about CC and what steps will need to be taken"	Developing an adaptation and mitigation plan	This complete guidebook and included toolkit
"has no control over the management of environmental issues within your service delivery area"	Commencing a consultative process with all stakeholders aimed at developing a CC adaptation and mitigation plan for your area of supply	Chapter 7 (Planning for Climate Change) of this guidebook
"have set some benchmarks and targets related to performance"	Incorporating additional benchmarks and targets that include for CC adaptation and mitigation	Performance Indicators for Water Supply Services, Manual of Best Practice[22] Performance Indicators for Wastewater Services, IWA Publishing[23]
"have various ideas about building resilience to CC but have not taken any action"	Appointing a CC Manager who will take ownership for developing a CC adaptation and mitigation plan	Chapter 7 (Planning for Climate Change) of this guidebook

[21] A Compendium of Best Practices in Water Infrastructure Asset Management: JN Bhagwan: Global Water Research Coalition, 2009

[22] Performance Indicators for Water Supply Services, Manual of Best Practice: Alegre, H. , Hirner, W.,Baptista, J. and Parena, R.: International Water Association, 2000 – IWA Publishing

[23] Performance Indicators for Wastewater Services: Matos, R., Cardoso, A., Ashley, R., Duarte, P., Molinari, A., Schulz, A.: International Water Association, – 2003 IWA Publishing

Worksheet # 1		
Your Utility…	**Then think about…**	**Resources available to you…**
"has developed an infrastructure investment plan"	Incorporating CC adaptation and mitigation into your investment plan by undertaking a vulnerability assessment	Chapter 8 (Assessment of Climate Change Risks and Vulnerabilities) of this guidebook
"has developed an asset management plan"	Including adaption and mitigation measures in your planning of new infrastructure	Chapter 8 (Assessment of Climate Change Risks and Vulnerabilities) of this guidebook
"has completed a vulnerability assessment related to Climate Change"	What adaptive and mitigation measures need to be taken and include same measures in your infrastructure investment plan	Costing the Impacts of Climate Change in the UK: Implementation Guidelines, UKCIP, 2004[24]
"has developed a disaster management plan"	Translating the identified risks into a CC vulnerability assessment towards the development of a CC adaptation and mitigation plan	Chapter 8 (Assessment of Climate Change Risks and Vulnerabilities) of this guidebook
"is already experiencing the effects of climate change"	Not only dealing with existing impacts but how you will manage more intense impacts in the future as climate change intensifies	Climate Change and Urban Water Utilities: Challenges & Opportunities - published by the Water Sector Board of the Sustainable Development Network of the World Bank[25]

Assignment

Acquire and study the resource listed under the characteristic that most appropriately describes the status of your utility.

[24] Costing the Impacts of Climate Change in the UK: Implementation Guidelines, UKCIP, 2004

[25] Climate Change and Urban Water Utilities: Challenges & Opportunities - published by the Water Sector Board of the Sustainable Development Network of the World Bank

Interruptions in power supply have a negative impact on the utilities ability to provide an acceptable water and waste water service. Adaptation and mitigation options such as alternative clean energy sources including hydropower may provide a sustainable solution for utilities.

Picture of electricity supply to pump station at Kegati River Intake – Kisii Kenya

7.2 ASSESS THE STATUS AND CAPACITY OF YOUR UTILITY TO UNDERTAKE A CLIMATE CHANGE ADAPTATION AND MITIGATION PLAN AND IMPLEMENT PROCESS

Completion of this module is optional and may not be applicable to small-scale utilities where management processes and operations are insufficient and/or planning protocols are not sufficiently developed. An intuitive understanding of the preparedness of your utility to deal with the impacts of climate change may be of more value than completion of this module.

Module Objective

Help utilities identify their level of readiness and control over four key management areas, namely infrastructure, financing, information, as well as strategy and planning that are crucial to CC planning.

Overview

As a forerunner to planning for climate change, a **Preliminary Readiness Assessment** (PRA) should be undertaken to assess four core management competencies (aggregated into separate 'Assessment Areas' - see adjacent figure).

Preliminary Assessment Areas
1. Strategy & Planning for Climate Change 2. Financing and Investment 3. Status of Infrastructure 4. Information on Climate Change

The assessment of these areas will help you – and your utility – understand your preparedness for climate change and enhance the development of a CC adaptation and mitigation plan. Information required to complete the PRA should be easily accessible although there may be a need to gather additional information from other departments and offices.

Assessment Areas and Parameters

The 4 **assessment areas** represent different *management competencies* that influence the ability of your utility to build CC resilience. For each assessment area (and each identified *parameter* listed under that area), you or your utility needs to evaluate two aspects, namely:

- ***Ability** to achieve the identified parameter:* is the ability of your utility to achieve the stated parameter. It is a measure of the authority or control your utility possesses in affecting the outcome of the parameter.
- ***Achievement*** refers to the level of progress your utility has made towards achieving the parameter. Parameters are stated as the ideal, i.e., as if your utility had achieved the identified parameter and was totally prepared to deal with the impacts of climate change.

Your evaluation for both ***Ability*** and ***Achievement*** is based on a five-point scale (or a weighting of between 1 and 5) defined as follows:

Ability (or capacity) to achieve parameter:
0: No direct control over achieving the outcome of the parameter
1: No direct control over achieving the outcome, but is involved stakeholder consultation
2: Control over the implementation, but no authority to set objectives for the indicator
3: Control over implementation, with some input in planning stages of indicator
4: Control over implementation and planning, but final approval lies with outside authority
5: Full direct control (financing, planning, and implementation) in achieving the outcome of the indicator

Achievement:
0: Non-existent
1: Utility has begun to develop a strategy to achieve the parameter
2: Utility has developed strategy, but has not implemented
3: Utility has begun implementation, but has not completed
4: Utility has fully implemented within its abilities, but has not achieved parameter
5: Achieved

Each parameter within each assessment area has been assigned a *weight* to represent its relative importance to the management competency in question. Utilities are encouraged to review these weights to best fit their situation. Parameters can also be reviewed and added to/subtracted from as deemed fit by the utility.

Rating each parameter allows your utility to identify weaknesses and gauge overall ability to make improvements and build CC resilience.

The Assessment Area for ***Strategy & Planning*** for Climate Change with parameters is displayed in Table 7-2 below.

Table 7-2: Parameters for Strategy and Planning

Strategy & Planning	Ability (capacity) to achieve Parameter	Achievement	Weights
Utility has established business plans that include climate change adaptation and mitigation			25%
Utility has established *short-term* infrastructure plans that include climate change adaptation and mitigation			10%
Utility has established *long-term* infrastructure plans that include climate change adaptation and mitigation			20%
Utility has established staff development plans incorporating climate change adaptation and mitigation			15%
Utility have established a communication plan to disseminate information about climate change *impacts*			15%
Utility have established a communication plan to disseminate information about climate change adaptation and mitigation			15%

The Assessment Area for Financing and Investment with parameters is displayed in Table 7-3 below.

Table 7-3: Parameters for Financing and Investment

Financing	Ability (capacity) to achieve Parameter	Achievement	Weights
Utility has reached full cost-recovery in operations and maintenance	3	5	50%
Utility has budget allocation for climate change projects	3	0	20%
Utility has access to government financial support for climate change projects	3	1	10%
Utility has access to donor financial support for climate change projects	4	3	10%

Financing	Ability (capacity) to achieve Parameter	Achievement	Weights
Utility has internally funded (loans, revenue) support for climate change projects	1	0	10%

The Assessment Area for Climate Change Information Systems with parameters is displayed in Table 7-4 below.

Table 7-4: Parameters for Information Systems on Climate Change

Information Systems	Ability (capacity) to achieve Parameter	Achievement	Weights
Utility is measuring meteorological data	4	1	5%
Utility is measuring trends in available water resources	4	3	15%
Utility reports climate change data to national authorities	1	2	10%
Utility belongs to information sharing network for regional water management	3	2	5%
Utility conducts audits on its water infrastructure performance	5	4	20%
Utility has water efficiency programs	4	3	10%
Utility has education resources available for the public on water conservation	4	3	5%
Utility has created forecasts for future water demand	5	5	20%
Utility monitors infrastructure on a regular basis	5	4	10%

The Assessment Area for the Status of Infrastructure with parameters is displayed in Table 7-5 below.

Table 7-5: Parameters for Infrastructure

Infrastructure	Ability (capacity) to achieve Parameter	Achievement	Weights
Utility has infrastructure to operate under extreme climate conditions	4	1	10%
Utility has redefined operating standards that incorporate potential climate change impacts	4	0	5%
Utility has implemented climate change operating standards	4	0	5%
Utility currently employs staff with adequate climate change knowledge	4	3	5%
Utility maintains water infrastructure	5	4	10%
Utility infrastructure has additional capacity to cope with climate change impacts	3	0	15%
Utility infrastructure has additional capacity to cope with forecasted demand growth	3	4	15%
Utility has low levels of UAW in comparison to relevant benchmark	4	2	10%

Infrastructure	Ability (capacity) to achieve Parameter	Achievement	Weights
Utility meets present water demand	3	3	10%
Utility has climate-resilient power infrastructure	1	3	5%
Utility has identified climate-vulnerable points within the water system	5	3	10%

Results of the PRA

Using the Excel spread-sheet included in **Appendix C** the outcome of the PRA generates a four-quadrant spatial chart that positions the Assessment Areas according to adaptive ability (capacity to implement) and achievement, as per the example given in Figure 7-2 below. The chart will act as a visual aid to help your utility select the *priority areas* for the next stage of the CC adaptation and mitigation process.

Utilities should not select their priorities solely on the basis of the PRA, but should incorporate stakeholder consultation, governance, and climate change policy analysis.

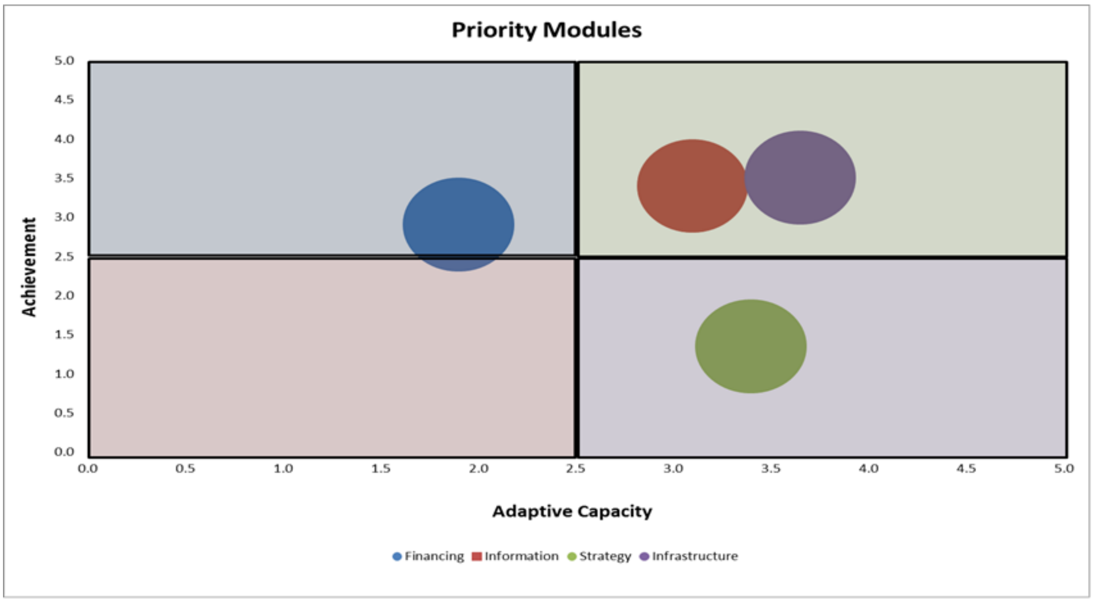


Figure 7-2: An example of how the results of the PRA will be rendered graphically.

Interpretation

Interpretation is based on the example given in Figure 7-2 above.

Results of Figure 7-2 illustrate that *Strategy & Planning* would be the main focus of the utility in question. This competency is positioned at a relatively high level of adaptive capacity (or ability to implement), but with a low level of achievement. The PRA indicates that the utility has not made sufficient progress within this competency, but *has the potential to do so*.

The Information and Infrastructure competencies are situated in the high adaptive capacity and achievement quadrant, demonstrating the utility's relative high level of performance in both these areas. The Financing competency is also at a moderately high level of achievement, but its adaptive capacity is lower than the other competencies. This suggests that its performance is dependent on outside forces, possibly from donor and government support.

While the PRA will support utilities in understanding their vulnerabilities, it is up to utilities to *take action*. It should be understood that some climate change actions will require external support through funding, policy change, use of consultants or capacity building. However, utilities do have authority and adaptive capacity (ability) over several management areas. This gives them the opportunity to make changes now and protect themselves from the impending negative climate change impacts. Depending on the outcome of the PRA and further detailed assessment, utilities will also gain clarity over areas that are essential for climate change preparedness, but need external support. Many utilities are uniquely positioned to take advantage of the already necessary utility upgrades (infrastructure, financing, policy), and can proactively apply a climate change lens to current and future programmes.

Assignment

Complete a **Preliminary Readiness Assessment** for your utility following the process described above and making use of the Excel Spread-sheet included in **Appendix C**.

The recent drop in water level of Lake Victoria (2006) had a negative impact on some of the region's utilities who draw raw water from the lake

Picture of upgraded raw water intake at Custom – Bukoba, Tanzania (BUWASA)

7.3 ESTABLISH A CLIMATE CHANGE TEAM AND PROGRAMME LEADERSHIP

Module Objective

Establish a core team and effective leadership for the formulation of a CC plan.

Overview

Critical to the planning process, is the establishment of a CC team with effective leadership. This team should be made up of individuals at your facility that can help facilitate the process and implement the necessary intervention measures. They should be knowledgeable of utility processes and representative of core utility functions such as maintenance, planning, metering and billing, revenue collection and expenditure. Top and middle management should be represented. This team will play an important role in planning, delegating tasks, establishing deadlines, collecting and evaluating work, providing training and also mentoring other staff involved in the process.

Team members should possess the following attributes:

- Enthusiasm and commitment to the process
- Knowledge and expertise of their core operational and functional areas
- Good communication and listening skills
- Respect and trust of and by colleagues as well as management

Team members can either be delegated / assigned to the CC team or they can volunteer to serve on this same Team.

The CC programme should be led by the CC Programme Manager and together with the CC Team they should champion the process.

Selecting a CC Programme Manager

Success of any project is often dependent on one person showing initiative and becoming a *project champion*. This person should be someone who is effective at leading projects, who can take responsibility, and who has an appropriate level of management authority to get the job done.

This person should also possess:

- Good project management, organizational and communication skills,
- A thorough knowledge of utility operations
- An ability to listen to others who have different perspectives and ideas.

Since the CC Programme Manager will need to assume new responsibilities, management should understand assigned responsibilities and be willing to redistribute existing responsibilities to others in the organization.

In addition to normal project management responsibilities, the CC Programme Manager will:

- Build and lead the CC Team,
- Plan the project and implementation schedule,
- Gather, organize, and disseminate information,
- Delegate tasks and establish deadlines,
- Facilitate interaction between the various departments and obtain buy-in,
- Facilitate meetings and communiqué about the project with all stakeholders, and

- Ensure drafting and finalization of the CC plan.

Assignment

In kick-starting the CC adaptation and mitigation process, the CC Team should undertake a preliminary readiness assessment of the utility as described and outlined in **Module 7.2** above.

7.4 SECURE STAKEHOLDER COMMITMENT AND INVOLVEMENT

Module Objective

Establish stakeholder commitment and involvement in the development of a utility CC adaptation and mitigation plan.

Overview

It is essential to involve stakeholders and gain support for the development and implementation of a CC adaptation and mitigation plan. Involving individuals who have current and/or past experience of coping with and adapting to climate variability and extremes is especially helpful in guiding the adaptation process. It may also be advisable to include technical experts on climate change and its consequences.

Support from important stakeholders such as senior and middle management, local political representation, participating NGO's, National Water Corporations, Departments and Authorities and/or Regional Water Boards is essential to ensuring "ownership" of decisions made, ultimately making the process more sustainable. Without adequate stakeholder support, your adaptation attempts may very well meet with resistance or prove to be unsuccessful.

Bringing stakeholders together to participate in identifying, evaluating, and making decisions on adaptation options is essential and enables a shared understanding of the issues and the reaching of consensus. The individual expectations and goals of identified stakeholders should be established and clarified to facilitate collaboration and build trust.

By understanding motivational factors behind decisions made, such as cost reductions, operational efficiencies, aspirations, it will be possible to align the CC plan to existing business processes and utility priorities.

Confirm that stakeholders understand:

- The CC adaptation and mitigation plan framework,
- The type, level and frequency of communication required during all phases of the project,
- The level of effort and time commitment that will be required from employees,
- The possible alignment of the CC plan to existing programmes, processes and utility plans.

Application

The most common approach to stakeholder involvement entails a stakeholder meeting or workshop in which a range of stakeholders are brought together to discuss various aspects of the adaptation plan and implementation. Stakeholder engagement can vary from passive interaction to self-mobilization in which the stakeholders assume ownership of the process and initiate design.

In embarking on a stakeholder participation process, management should assume responsibility for:

- Accepting and displaying leadership and commitment to the process,
- Designating staff members and assigning responsibilities,
- Establishing levels of authorization,
- Recognizing effort and contribution.

Assignment

Through a consultative process engage identified stakeholders in the planning phases for the development of the CC adaptation and mitigation plan.

7.5 REVIEW NATIONAL AND LOCAL LEGAL AND COMPLIANCE REQUIREMENTS

Module Objective

Identify legal and other requirements that may affect operations and CC compliance status.

Overview

An important aspect of planning for climate change is knowing local legal and compliance requirements for utility operations. These requirements can significantly affect the nature and scope of your CC adaptation and mitigation plan.

What are the requirements that a utility must follow? Some examples:

- Compiling of a Water Services Development Plan,
- Compiling of a Water Safety Plan,
- Reporting on NRW or UAW,
- Maintaining a minimum level of service,
- Ensuring workers health and safety,
- Attainment of a certain quality of treated water or wastewater, and
- Environmental monitoring and reporting as well as the documentation of compliance.

Application

Compile a list of known compliance requirements for your utility. Then for each one, ask the following:

- What is required of our utility? What can we do to achieve compliance?
- What government ministry or entity has enacted this requirement?
- Are we already complying with this requirement? If so what do we need to do to maintain compliance?
- What can we do to improve compliance?
- Does compliance with the requirement increase or decrease our vulnerability to climate change?

An example check sheet to record the compliance requirement is provided in Table 7-6 below.

Table 7-6: Worksheet # 2: Check sheet to record compliance requirement

Worksheet # 2	
Compliance Requirement Name:____	
Requirement	
Are we in Compliance (Y/N)?	
Relevant Ministry (state, provincial, regional, local)	
Effective date of requirement including revision date as appropriate	
Could we improve our performance?	
Are applicable regulations changing or being updated?	

Worksheet # 2	
Compliance Requirement Name:____	
How does this affect our proposed climate change plan?	

Assignment

Using the example table above and the blank regulatory requirements table in **Appendix A**, fill in the information for your utility for each identified compliance requirement.

7.6 ESTABLISH AN APPROPRIATE CLIMATE CHANGE GOAL AND RELATED TARGETS

Module Objective

Establish a climate change adaptation and mitigation goal and targets towards achieving same goal and align these to existing operational and infrastructure investment plans and programmes.

Overview

It is important to set a specific goal (and targets to work towards achieving same goal) that will ensure improved climate change resilience. Climate change adaptation and mitigation goals should not be seen in isolation to the normal operations of the utility. In reality planning for climate change translates into an *improved operating regime* which is more resilient to all types of risks including operational risks, risks associated with natural disasters, as well as those linked to long term changes in the climate.

An example of an appropriate CC adaptation/mitigation goal would be

> **"Reduce major risks and vulnerabilities associated with climate change that may affect the current operating regime within a five year period."**

In drafting a CC goal, vague and generic statements should be avoided; rather the goal should be specific in terms of what you hope to accomplish.

The goal should represent a stated commitment to CC adaptation/mitigation and a continual improvement process. It should provide a vision for the entire utility and inform all aspects of the CC plan.

Hold a focus meeting with your CC team to brainstorm a CC planning goal. Make sure all stakeholders are invited to the meeting.

Alignment to Existing Goals and Targets of the Utility

Once a CC adaptation goal has been proposed, make sure the goal is aligned to your utility's mission, goals, and strategic direction.

Strategically, does your utility or controlling authority want to -

- Reduce dependence on erratic electrical supply?
- Conserve water resources?
- Demonstrate leadership in improving operations?
- Become more environmentally responsible?
- Help your government implement a national climate change adaptation plan?
- Improve the image of the utility in the eye of the public?
- Set an example for other utilities in the region or neighbouring countries?

If you have answered yes to any of these questions, your goal to become more resilient to CC is probably aligned to the strategic direction of your utility and can then easily form part of existing level of service programmes, as well as infrastructure investment and operational plans.

You may want to confirm whether your utility or community has a Climate Change Action Plan linked to ICLEI. ICLEI tracks some cities' adaptation to CC and has info on some communities.

Click on the link provided below and enter your region to see if your town/city is a member of ICLEI and whether or not an action plan has been developed for you.

(http://www.iclei.org/index.php?id=1387&region=Africa)

Setting Targets

Having established your CC Team, instituted an appropriate measuring protocol, defined and stated a CC goal to work towards, it is now necessary to set targets towards achieving your stated goal. There are no standard targets for water and wastewater utilities. Your targets however should reflect your level of operation and current performance, as well as what your utility wants to achieve.

As with all tasks, your targets should be SMART:-

- *Specific*
- *Measureable*
- *Accurate*
- *Realistic*
- *Time-related*

An example of specific targets related to CC adaptation/mitigation is provided in theTable 7-7 below:

Table 7-7: Example of CC adaptation targets

Objective and Target	Timeframe
Reduce the use of electricity from the national grid by 25%	2 years
Increase the size of potable water storage facilities to allow for 96 hour storage capacity	5 years

Other factors to consider when setting targets:

- Existence of a measurement baseline
- Ability to control
- Ability to track/measure
- Cost to track/measure
- Progress reporting

Assignment

In consultation with the CC Team, develop an appropriately defined goal that will inform the various components of your CC plan. Also develop specific targets that are informed by your CC plan. Use the worksheets provided in **Appendix A** for this purpose.

7.7 CHOOSE APPROPRIATE BENCHMARKS, PERFORMANCE INDICATORS AND COLLECT BASELINE DATA

Although a benchmarking process involving the establishment and measurement of KPI's is proposed in terms of this guidebook, it is likely that your utility is already benchmarking performance independent of the CC planning process. Ideally the CC planning process should only lead to the addition of a few appropriate KPI's, not previously measured or monitored by your utility.

Module Objective

Establish appropriate benchmarks against which achievement of CC resilience can be measured and monitored.

Overview

Benchmarking allows you to measure not only your own performance in achieving set goals and targets, but also to compare your performance against other utilities of similar size and composition.

Certain Key Performance Indicators (KPI's) related to selected benchmarks should be identified and the necessary measuring and monitoring protocols instituted to ensure that performance can be measured. It is also critical to establish a baseline measurement for the KPI against which progress in attaining the set goal can be measured.

The first step in collecting baseline data is to determine what data is already available. For KPI's related to normal operational processes, at least one year's data (disaggregated into monthly figures) should be captured in a format most suitable for the measuring of performance.

Examples of data elements used in calculating KPI's are:

- Volumes of water/wastewater supplied/collected by your utility,
- Electricity consumed in supplying treated water and collecting effluent wastewater,
- Quantities of fuel used over and above electricity (such as diesel, petroleum, gas etc) in supplying water to customers as well as treating and transporting wastewater.
- Specifications for key infrastructure components such as pump stations, water and wastewater treatment works,
- Operating schedules,
- Non-Revenue Water (NRW) volumes and percentages
- Unaccounted for Water (UAW) volumes and percentages

Typical performance indicators and benchmarks for water and sanitation utilities that could potentially be used to measure the success of climate change adaptation/mitigation for your utility are listed in Table 7-8.

Table 7-8: Typical benchmarks and performance indicators

Typical Benchmarks and Performance Indicators						
No	**Category**	**Description**	**Calculation**	**Unit**	**Timing**	**Definitions**
1.	Customer Coverage	Percentage of total population served with potable water	No. of people served / total number of people x 100	%	Annual	Number of people served by utility and receiving potable water within area of supply.
2.	Service Reliability	Supply infrastructure failures	Total number of supply infrastructure failures	#	Month	Supply infrastructure failure covers all plant, works and pipelines.

Typical Benchmarks and Performance Indicators						
No	**Category**	**Description**	**Calculation**	**Unit**	**Timing**	**Definitions**
3.	Water Tariff : Retail Water	The weighted average tariff charged by the utility	Total amount charged for potable water for the year / the total volume charged for in Mℓ	$/m^3	Annual	Average tariff is the proportional tariff charged over the 12-month period.
4.	Financial Efficiency	Collections efficiency	Total amount received / total amount billed in accounting period x 100	%	12-month Moving Ave	
5.	Profitability	Operating surplus	Net income / operating revenue x 100	%	Year-to-Date	
6.	Energy Consumption	Total Energy	Total energy consumption in kWh / m^3 distributed	kWh/ m^3	Month	
7.	Energy Efficiency	Energy cost	Total electricity costs / m^3 of water put into supply	$/ m^3	Month	Energy cost is the total amount of electricity cost incurred by the water utility.
8.	Water Balances	Unaccounted for water	Quantity of water abstracted from the primary source less the water sold / Actual water production at treatment works x 100	%	Month	Actual water production is the quantity of water abstracted from the primary source less water lost in treatment.
9.	Production Costs	Cost of water production (in Mℓ)	Total operating cost / volume of water treated (in Mℓ)	$/Mℓ	Quarterly	
10.	Equipment Availability	Assurance of supply – water treatment	Available water treatment capacity / annual average daily demand x peak factor	#	Annual	Equipment Availability is to be reported per scheme.
11.	Water Quality	Percentage of potable samples failing to meet given standards	Total no of samples failing to meet specified criteria / total no. of samples x 100	%	Month	Criteria may be any set of criteria appropriate to the class of water being sampled and duly published in advance.
12.	Raw Water Abstraction	Percentage of utilised capacity to installed capacity	Utilised in m^3/d / installed m^3/d x 100	%	Annual	Installed capacity is the total infrastructure in place. Utilised capacity is the actual water supplied.
13.	Pumping Systems: Installed	Percentage of utilised capacity to installed capacity	Utilised in m^3/d / installed m^3/d x 100	%	Annual	
14.	Water Sales	Water sold	Average number of Mℓ sold on a monthly basis	Mℓ	Annual	
15.	Meter Coverage	Percentage of system covered by meters	No. of metered connections / total number of connections x 100	%	Annual	

Typical Benchmarks and Performance Indicators						
No	**Category**	**Description**	**Calculation**	**Unit**	**Timing**	**Definitions**
16.	Rural Networks	Percentage of total sales from rural reticulation schemes	Rural reticulation sales / total sales x 100	%	Annual	Rural refers to areas outside of proclaimed townships.
17.	Environmental Management	Extracted water quality	Are policies in place to monitor raw water quality?	Y/N	Annual	

A more comprehensive list of benchmarks and performance indicators is provided in **Appendix B**.

The International Water Association (IWA) has published manuals of best practice related to performance indicators for water supply services[262]and wastewater services[27] which can be referred to for additional information on this topic.

Assignment

Select an appropriate list of benchmarks and performance indicators for your utility that could be used to measure and monitor performance and success in adapting to the possible impacts of CC. Your utility must feel comfortable with the indicators and should be able to measure them with a fair amount of ease. Remember that when it comes to KPI's and benchmarks, less is more. You are encouraged to minimize the number of indicators and benchmarks you are going to use.

Your utility may already have selected certain indicators and have a measuring protocol in place. Some of these indicators could serve a dual purpose and be used to measure progress in CC adaptation. If not, this may be the opportunity to add some additional key indicators specifically for this purpose. It is recommended that stakeholders are consulted when selecting performance benchmarks.

The installation of certain measuring devices such as water meters and data loggers may be required to enable the implementation of this activity. It may also require the generation of management reports from IT systems.

[26] Performance Indicators for Water Supply Services, Manual of Best Practice: Alegre, H. , Hirner, W.,Baptista, J. and Parena, R.: International Water Association, 2000

[27] Performance Indicators for Wastewater Services – 2003 IWA Publishing

7.8 ALIGN THE MEASURING REGIME TO SELECTED BENCHMARKS/KPI'S AND ESTABLISH BASELINES

Module Objective

Implement a measuring regime that identifies, locates and assembles information for selected benchmarks and performance indicators and allows for the establishment of appropriate baselines.

Overview

> **"To measure is to know.."**
> **Lord Kelvin**

For progress to be made in achieving goals, targets and resilience to CC, it is essential that information relating to selected performance indicators be gathered. This may require the implementation of a measurement protocol that includes data gathering and logging at an agreed to interval and the installation of key components such as bulk water meters. With the establishment of a measurement protocol, it will be possible to determine baselines, against which progress towards achieving goals, targets and the implementation of CC adaptation/mitigation can be measured. Oftentimes, a history of certain measurements over a minimum acceptable time period is needed before baselines can be established. The minimum time period should cater for seasonal fluctuations which may be experienced.

If sufficient data over a minimum time period is unavailable, use what you have or what you can easily collect.

Several essential data elements that should be collected and tracked over time include (but are not limited to):

- **Stream-flow and hydrological data** for each abstraction point.
- **Bulk water supply and treatment volumes** (or flows) are essential to understanding your operation.
- **Overall volumes of treated water supplied** by the utility.
- **Volumes of water sold** disaggregated into the various categories of customers.
- **Revenue collected** including payment levels.
- **Electricity usage data** including load profiles providing for overall consumption and peak demand.
- **Other energy data** such as diesel usage for electrical generation.
- **Water quality testing results** undertaken for both water and wastewater treatment processes.

These elements should be translated into useful data that is aligned to the selected Performance Indicators. Also for most of the elements, as a minimum, monthly data is required.

The use of Supervisory Control and Data Acquisition (SCADA) systems can greatly assist in providing some of the data required. If such a system is installed in your utility it may be prudent to extend the system to include some of the essential elements required for the benchmarking and performance management system.

Assignment

Develop a measurement protocol for your utility using Worksheet # 3 (Table 7-9) below which is also included in **Appendix A**.

Table 7-9: Worksheet # 3: Measurement Protocol for performance indicators and establishment of baselines

Worksheet # 3						
No.	**Data Required**	**Units**	**Performance Indicator**	**Desired Frequency**	**Source**	**Availability**
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Once the table has been populated it can be used to calculate each of your selected indicators. Indicators can then be translated into graphical form to help establish baselines and detect trends or patterns over time.

Determination of Baselines

It is essential that baselines be determined for each indicator. The only way your utility's performance can be measured over time is to establish appropriate baselines. Make sure you establish a baseline for each of the indicators against which progress can be measured. In real terms, the baseline should be established before setting any goal or target you aim to achieve through the CC planning process.

For example, you may want to measure the volume of unaccounted for water (UAW) in your system, which is the difference between the volume of water supplied and the total volume of water sold over a defined period of time, stated as a percentage. If your utility has embarked on a meter replacement programme, you will want to record the level of UAW before installing the customer meters as you will then be able to establish the impact of the intervention on the level of UAW.

Do you have all the data and information for measuring performance indicators and establishing baselines for each? If not, what level of effort is necessary to obtain the necessary data? You may find that no baseline data exists. If so do not let this stop you in moving forward. Determine a plan of action to establish the baseline you require.

Graphical representation may be particularly helpful in presenting results to the CC Team and other Stakeholders. If there are changes attributable to a known intervention, then this should be highlighted.

Are there any daily or seasonal variations that need to be accounted for?

Assignment

Using the completed worksheet # 3 (Table 7-9 above), establish a baseline for each of your selected benchmarks and performance indicators.

Installation of bulk as well as customer meters for the purpose of management and revenue collection form an integral part of a water utilities operations. A comprehensive water balance allows the utility to make critical decisions regarding water demand and set performance targets relating to water losses and non-revenue water.

Picture of Meter Calibration Facility – Sensus Metering Systems, Johannesburg South Africa

8 ASSESSMENT OF CLIMATE CHANGE RISKS AND VULNERABILITIES

In this chapter users of this Guidebook are provided with instruction on how to carry out a climate change vulnerability assessment at the appropriate level of detail and rigour. This involves:

- *Compiling a detailed description* of your water and waste water system
- *Identifying the risks* you may be exposed to as a result of climate change
- Assessing the *likelihood* of the event (or problem) occurring (now and in the future as climate change intensifies), as well as understanding the *current and future impact* the event will have on your operations.
- *Completin*g the Vulnerability Assessment and Adaptation and Mitigation Work Sheet
- Establish Current and Projected Demand and Supply Using The WEAP Model

These are the first necessary steps in developing a comprehensive and robust adaptation and mitigation plan for your utility. The utilities operations are divided into the three operational areas, namely technical, financial and institutional and the risks and associated vulnerabilities for each are assessed. Adequate consideration must be given to both the present as well as future risks and vulnerabilities faced by the utility for the three operational areas.

8.1 COMPILE A DETAILED DESCRIPTION OF YOUR WATER AND WASTE WATER SYSTEM

Module Objective

Develop an up to date and detailed description of the water and waste water system in order to identify risk

Overview

Your utility should begin by identifying risks and associated vulnerabilities relating to technical aspects of service delivery. In order to do so, it is necessary to compile a detailed description of the water and waste water system. By completing this process, the utility will have a thorough and up to date understanding of the water and waste water system and will consequently be able to undertake the process of assessing the vulnerabilities.

8.1.1 Water Supply System

The description of the water supply system should include the following:

- Detailed schematic of the water supply system indicating all bulk pipelines, reservoirs, pumps stations, meters and areas/ large consumers. This should accurately illustrate the flow of water from source to point of use
- Description of the operation procedures for the system
- Details of land use within the catchment
- Sources of water and details of any interconnectivity of water from different sources in to the system
- Abstraction process used
- Water treatment including the process and chemicals/ materials used for purification
- Water quality measurement points, frequency of tests and quality standards used
- Details of types, size, age, type of lining and condition of all distribution pipelines
- Details of the capacity, types, size, age, level control and condition of all reservoirs

- Details of the type, capacity, age, maintenance schedule and condition of the pump stations
- Water users and type of water use
- Water users who make use of alternative sources of water
- Operations and Maintenance Staff and their roles and responsibility in operating the system
- Process whereby system failures are identified, reported and resolved.

8.1.2 Waste water System

The description of the waste water system should include the following:

- Detailed schematic of the waste water system indicating all sewer pipelines, sumps and pumps stations, meters and large effluent contributors. This should accurately illustrate the flow of waste water from discharge to point of treatment and disposal
- Description of the operation procedures for the system
- Waste water treatment including the processes used
- Water quality measurement points, frequency of tests and quality standards used
- Details of types, size, age of all sewer reticulation
- Details of the type, capacity, age, level control, maintenance schedule and condition of the pump stations
- Users who make use of the services and type of effluent discharged
- Operations and Maintenance Staff and their roles and responsibility in operating the system
- Process whereby system failures are identified, reported and resolved.

This document may well be in existence (if the utility has already developed a Water Safety Plan[28]) and may only need to be updated. Field investigations should be conducted to ensure that the document is up to date before the process of identifying vulnerabilities can commence.

> ***Tip:*** *A Geographical Information System (GIS) can be extremely effective means of capturing, storing, analysing and reporting on spatial information and data relating to the utilities water and waste water system.*

[28] Water Safety Plan, Step-by-step risk management for drinking-water suppliers – WHO, IWA

Water Demand Management, including infrastructure audits, data logging and leak detection can assist the utility in identifying high water loss areas. Undertaking to reduce losses and improve efficiencies will increase the utilities level of resilience when adapting to climate change.
Picture of Field Audit Team – Nelson Mandela Bay Municipality Water Loss Programme, South Africa

8.2 IDENTIFY AND ASSESS ALL VULNERABILITIES TO UTILITY OPERATIONS

Module Objective

To identify and assess vulnerabilities of the utilities operations to climate change. Begin by identifying the vulnerabilities in the form of risks, state the problems relating to the risks and assess the probability of the problems occurring.

Overview

Some aspects of a utility's operations are more vulnerable to climate change than others. It is therefore important that you firstly identify all vulnerabilities and then go about prioritising the vulnerabilities in terms of the probability of the problem occurring. What the impact of the problem is and whether it has already been felt and is likely to be felt in the future will also determine the level of priority of the proble.

An initial assessment of the vulnerabilities can be used to identify specific areas within the utilities operations and systems that have higher levels of risk associated with them.

Vulnerability can be described as a function of three factors, namely exposure, sensitivity and capacity.

Exposure is the extent to which the utilities operations could be effected by climate change and also a function of the nature and severity of the climate change

Sensitivity is how the functioning of the utility would change once it is exposed to climate change.

Adaptive capacity is the ability of the utility to adapt to the changes in climate while maintaining an acceptable level of service to its consumers.

A utility that is therefore significantly exposed to climate change as well as sensitive to this change, will be less vulnerable if it has the necessary adaptive capacity.

8.2.1 How to Identify Vulnerabilities

It is necessary for the utilities to work with all relevant stakeholders in order to properly identify vulnerabilities. It is also important to ascertain the time frame for which the impacts of climate change are being considered. The longer the time frame, the higher the degree of expected climate change, and the more vulnerable the utility is likely to be.

The process of determining what aspect of the utility's operation is vulnerable is an important one as this will have an impact on the subsequent steps to be taken in the adaption plan.

The operation of the utility in terms of vulnerabilities can be classified as follows:

- Identified risks under the current climate that could be made worse by climate change
- Risks that have not yet been identified (or experienced) that may emerge as a result of climate change

It may be easier for your utility's stakeholders to identify vulnerabilities that are currently being experienced and are likely to be made worse by climate change. It is important to note however that there may be vulnerabilities that have not yet been experienced but may have a significant negative impact on the utility in the future.

The below Figure 8-1 illustrates the interconnected relationship between the three areas into which the utility can be separated, namely:

- Technical – primarily the function of the utility in the provision of water and waste water services to its customers

- Financial – the sourcing and management of funds by the utility, required to effectively provide water and services to its customers
- Institutional – the structures and mechanisms of the utility that are established to best meet the needs of its stakeholders (internal and external)

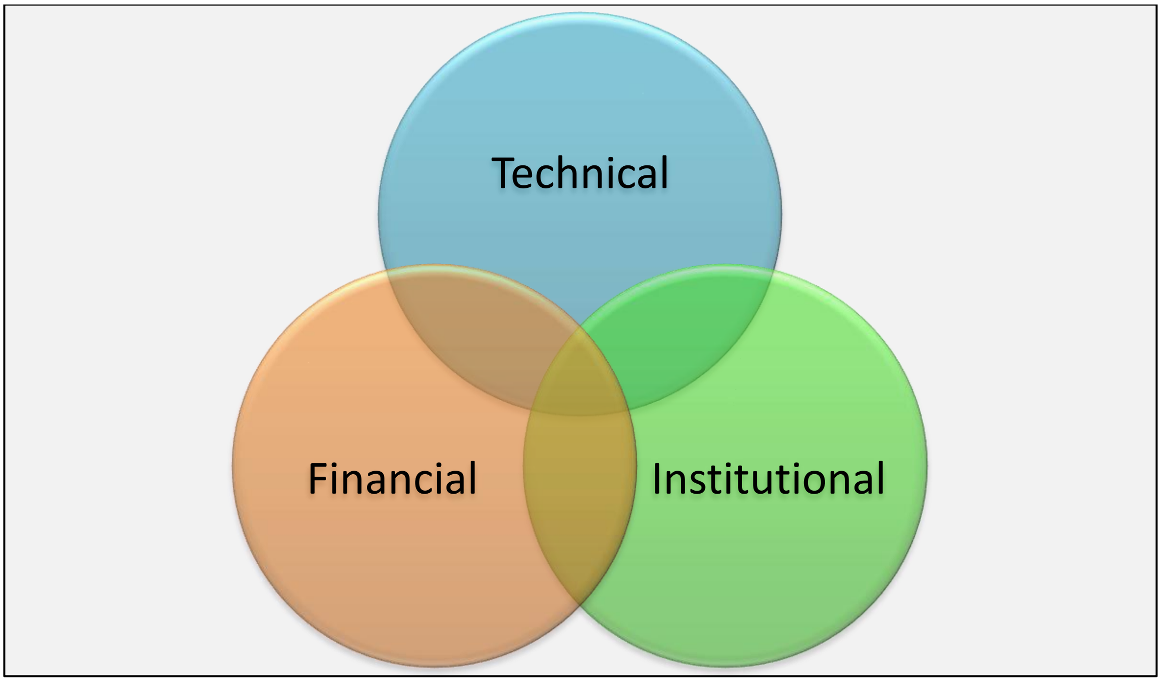


Figure 8-1: Interconnected relationship of the operational sectors within a utility

The process of dividing your utility's operations into these areas is the first step in assessing vulnerabilities.

8.2.2 Technical Vulnerabilities

The Figure 8-2 illustrates the cyclic system of the water and waste water process for a utility whereby the water is initially obtained from a resource (dam, river, borehole etc) and via the abstraction, treatment, storage and supply, the consumer, wastewater collection and wastewater treatment and discharge, is returned to the resource.

Potential vulnerabilities faced by utilities include flooding of intakes and water treatment plants located in or near river flood plains

Picture of Water Treatment Plant Intake - Masaka, Uganda

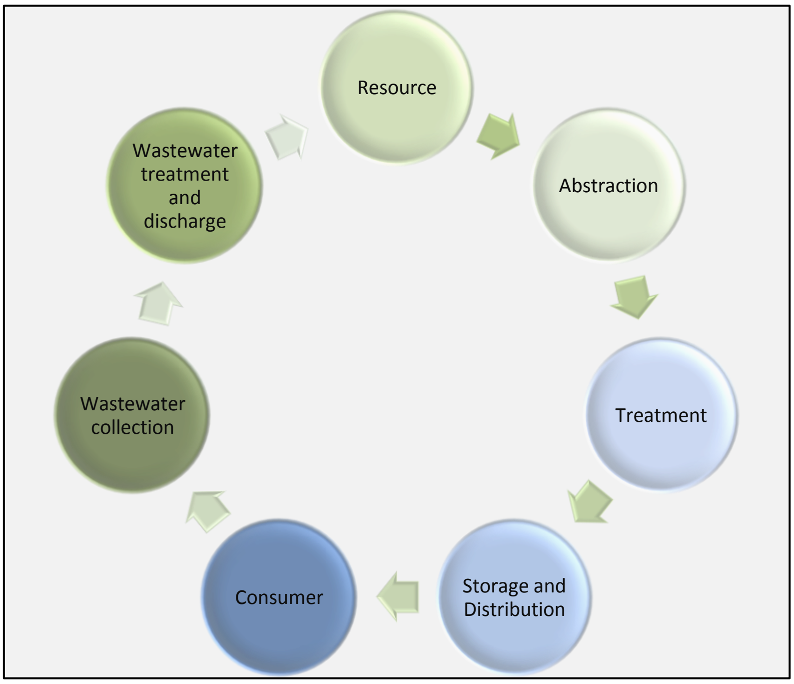


Figure 8-2: Water and waste water process for utilities

The vulnerabilities in terms of existing as well as potential risks for the sectors of the water supply and waste water system outlined in

Table 8-1, should be identified.

Table 8-1: Utilities Water Supply and Waste water System

Utilities Water Supply and Waste water System	
Water Resource	This will include the catchment when water is supplied from a river system, groundwater when well/ borehole water is used. Consideration must be given to other consumers competing for the same resource.
Abstraction	The point and process whereby the water us removed from the resource such as the pumping of water from a lake, dam/ reservoir or river weir.
Treatment	Once the water has been abstracted, the process whereby the water is treated before being distributed and/ or stored
Storage and Distribution	Storage and transportation of the treated water within the water supply system. This includes pumping and pressure reduction.
Consumer	Delivery of the treated water from the storage and distribution system to the consumer. Where applicable, the consumer may also store the water supplied
Wastewater collection	the collection and delivery/ disposal of wastewater upon discharge from the consumer to the wastewater treatment facility (where applicable)
Wastewater treatment and discharge	treatment of the wastewater before discharge into the water catchment

8.2.3 Financial Vulnerabilities

Once the process of identifying the technical vulnerabilities is complete, the financial vulnerabilities for the utility can then begin.

For the purpose of the vulnerability assessment, the financial sector is separated into the following areas shown in Figure 8-3 below.

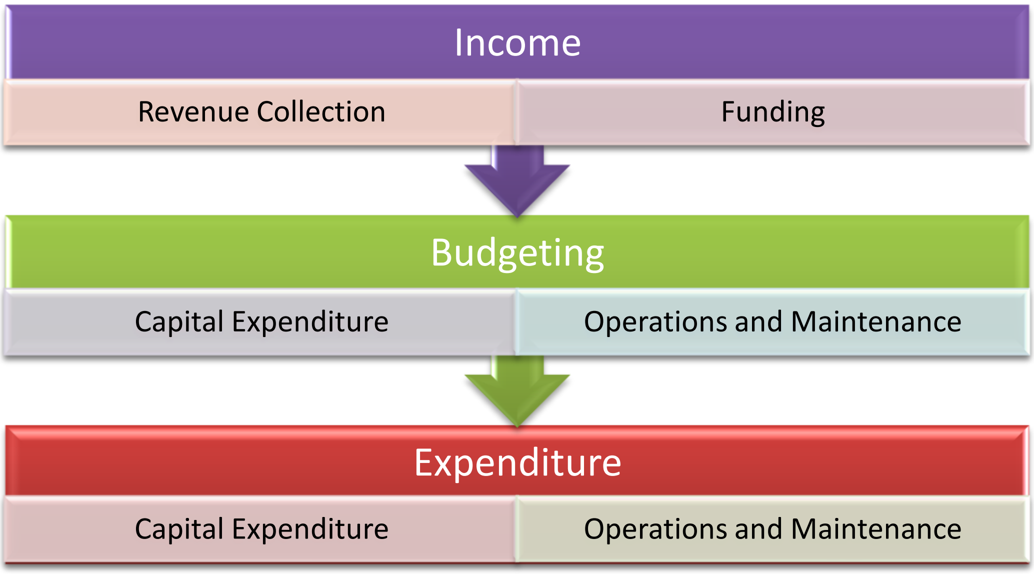


Figure 8-3: Financial sector

The vulnerabilities in terms of existing as well as potential risks for the financial sectors as outlined in Table 8-2 below should be identified.

Table 8-2: Utilities Financial Sector

Utilities Financial Sector		
Income	*Revenue Collection*	Income from billing of domestic, commercial, institutional and industrial customers for water and waste water services
	Funding	Income allocated annually from the government, donor funding and monies loaned from financial services (credit).
Budgeting	The means by which funds are allocated to the utilities departments, operations and projects. Budgeting is carried out, normally on an annual basis for capital expenditure and operations and maintenance.	
Expenditure	*Capital Expenditure*	These include costs for operations and maintenance; new, upgrading of and replacement of infrastructure.
	Operations and Maintenance	These are the annual costs incurred by the utility to operate and maintain the water and waste water system.

The utilities ability to budget for climate change adaptation measures is largely dependent on the sourcing of the necessary income. The utilities sources of income and in turn, its ability to budget for climate change adaptation is dependent to a large degree on its ability to procure income **billing system**. The ability of the utility to generate its own revenue reduces its dependence on external funding. The Figure 8-4 provides a flow diagram of the billing system which for most utilities is carried out on a monthly basis.

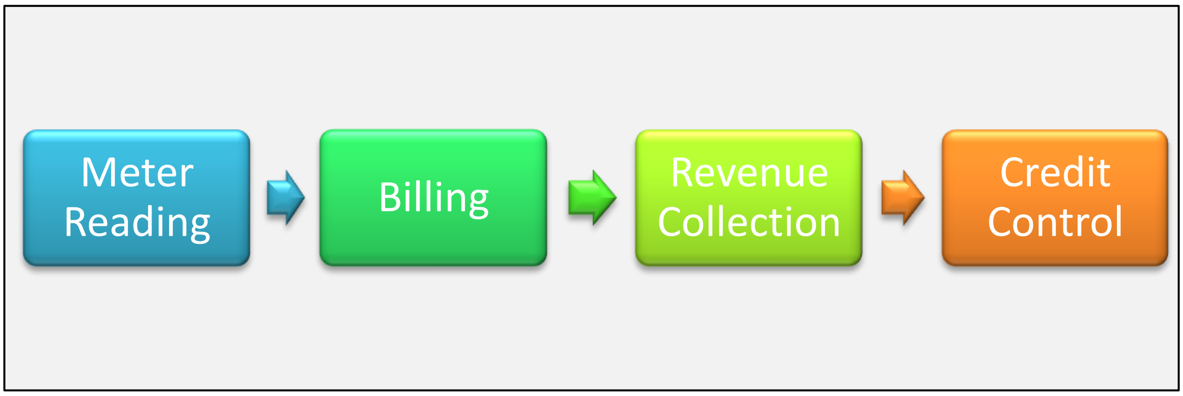


Figure 8-4: Financial sector – Billing system (Revenue Collection)

It is important that this system as described in the

Table 8-3 below is given adequate consideration when carrying out the vulnerability assessment of the financial sector.

Table 8-3: Utilities Financial Sector – Billing System

Financial Sector – Billing System	
Meter Reading	Consumer meters, both domestic and non-domestic meters are read on a monthly basis
Billing	The consumers are billed for their usage based on the difference in meter reading for the billing period and the utilities tariff structure
Revenue Collection	Revenue for the billed amounts must be collected from the consumers
Credit Control	A system of dealing with customers who default is implemented by the utilities

In addition to revenue collection via the billing system, your utility must consider vulnerabilities associated with procurement of income from government, donor funding and loans. Few utilities are able to operate on a sustainable basis without these external sources of income and the ability to source income for adaptation measures may have a significant impact on the success of the utility in dealing with climate change.

8.2.4 Institutional Vulnerabilities

Figure 8-5 below illustrates some of the main sectors that form part of the institutional functioning of the utility.

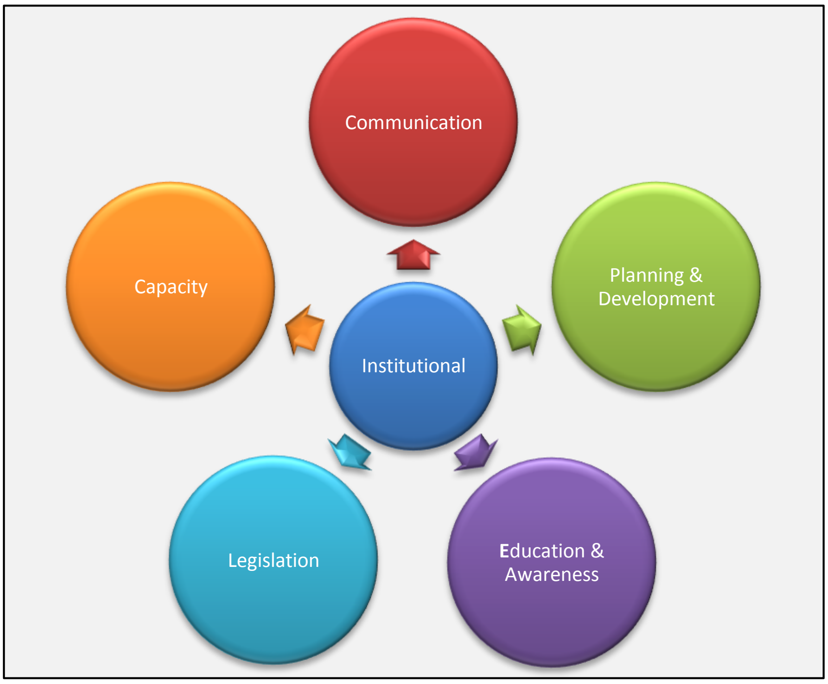


Figure 8-5: Institutional sector

The vulnerabilities in terms of existing as well as potential risks for the institutional sectors as outlined in

Table 8-4 below should be identified.

Table 8-4: Utilities Institutional Sector

Institutional Sector	
Communication	Utilities role of consulting with and keeping internal and external stakeholders informed
Education and Awareness	Providing stakeholders with access to information on climate change, water conservation and other issues relating to the utilities services
Capacity	Human resources and skills required by the utility to function across sectors
Planning & Development	Approach of dealing with changing/ increasing demands on the utility
Legislation	Regulatory framework within which the utility operates

Any additional sectors or operational areas identified but are not deemed to be Technical, Financial or Institutional are included in the vulnerability assessment as "other".

Other – this may include additional areas that are part of the water supply system that are not included above

8.2.5 Completing the Vulnerability Assessment and Adaptation and Mitigation Work Sheet

Worksheet # 4 (included in **Appendix A**) provides the utility with a structure to carry out the Vulnerability Assessment process in the form of risk identification and prioritisation for each of the aspects of the water supply system given above. The worksheet then addresses the adaptation process in term of planning and measurement in the next sections of the guidebook.

The Vulnerability section of the worksheet should be completed as follows:

Step 1: Vulnerability Assessment

Step 1.1: Risk

Each sector relating to the water and waste water supply system is assessed for existing and potential vulnerabilities. These vulnerabilities in the form of risks are identified and recorded for each of the water supply and waste water sectors (See ***Step 1.1.1: Risk Identification***).

Examples of typical risk for each of the technical aspects of the provision of services associated with the water supply and waste water system for consideration by the utility are provided in Table 8-5.

Table 8-5: Typical Risks for the Technical Sector

Technical Sector – Typical Risks		
Technical	**Water Resource**	Flooding
		Fluctuations in water quality
		Drought
		Chemical Contamination
		Microbial contamination
		Algae Blooms
		High raw water charges
	Abstraction	Power supply
		Pump Failures
	Treatment	Power supply

Technical Sector – Typical Risks		
		Telemetry/ Communication Failure
		Security
		Flooding
		Contaminated Treatment Chemicals
		Capacity of Treatment Works
		Water Quality (Reliability of Disinfection Process/ Filtration Process)
		Instrumentation/ Equipment Failure
		Inappropriate/outdated technologies
	Storage and Distribution	Valve/ Level Control Failure
		Water Theft/ Unauthorised Connections
		Leaking Reservoir
		Pipe burst/ failure
		Metering (Lack of/ failure/ inaccuracy)
		Leakage (Pipes/ Valves/ Hydrants/ Service Connections/ Meters)
		Telemetry/ Communications Failure
		Water Contamination
		System capacity
		Inadequate coverage of supply area
	Consumer	Contamination of supply through reverse flow
		Water Theft/ Unauthorised Connections
		Intermittent supply
		On-site storage and contamination
		Affordability of water
	Wastewater Collection	Blockages
		Pipe/ Pump Failures
		Flooding
		Lack of infrastructure (coverage)
	Waste Water Treatment and Discharge	Ingress of storm water
		Power supply
		Telemetry/ Communication Failure
		Security
		Flooding
		Capacity of Treatment Works
		Discharge Water Quality (Reliability of treatment process)
		Instrumentation/ Equipment Failure

Examples of typical risk for each of the financial aspects of the provision of services associated with the water supply and waste water system for consideration by the utility are provided in Table 8-6.

Table 8-6: Typical Risks for the Financial Sector

Financial Sector – Typical Risks		
Financial	**Income**	Reliability of the billing system
		Inadequate billing and revenue collection
		Tariffs not cost recovery related
		Security of funding
		Delays in obtaining funds
	Budgeting	Poor allocation of funding
		Laborious procurement processes
	Expenditure	Insufficient funds for CAPEX/O&M
		Insufficient control measures

Examples of typical risk for each of the financial aspects of the provision of services associated with the water supply and waste water system for consideration by the utility are provided in Table 8-7.

Table 8-7: Typical Risks for the Institutional Sector

Institutional Sector – Typical Risks		
Institutional	**Communication**	Inadequate consultation with stakeholders
		Shortage of customer surveys
	Education and Awareness	Insufficient knowledge of climate change impacts
		Insufficient knowledge of water conservation/water use efficiency options
	Capacity	Skills shortages
		Need for performance contracts
		Information technology systems are inadequate/outdated
	Planning & Development additive	Incomplete asset register
		High growth in populations
		High rate of urbanization
	Legislation	Regulations are outdated
		Lack of enforcement of regulations
		Non-compliance with legislation
	Other	Urbanization/population growth
		Competing water users

A problem statement relating to the identified risk is then created and entered into the next column (See ***Step 1.1.2: Risk Problem Statement Relating to Risk***). This statement describes the existing or potential problem relating to the identified risk.

The identified risk and associated problem statement must then be analysed in terms of whether it is already occurring, is highly likely to occur in the near future of is highly likely to occur in the longer term as a results of climate change (See ***Step 1.1.3: Probability***).

Step 1.2: Vulnerability

The next step is to assess the impact of the vulnerability, both current (the impact is already being felt) and future impact (the impact will be felt in the future - See ***Step 1.2.1: Impact***). It is important to again emphasise that there may be vulnerabilities that although not presently existing, will occur in the future as the impact of climate change increases.

Once the vulnerabilities have been identified, it is important that they are prioritised according to do the following:

- Those which are of the greatest concern to the stakeholders/ have the most significant consequences
- The impacts which are likely to be experienced sooner than others

Tip: For additional examples of vulnerabilities being experienced by various utilities around the world, see: Climate Change and Urban Water Utilities: Challenges & Opportunities **-** published by the Water Sector Board of the Sustainable Development Network of the World Bank

8.3 ESTABLISH CURRENT AND PROJECTED DEMAND AND SUPPLY USING THE WEAP MODEL

Module Objective

To establish current and projected water demand and supply

Overview

In order to complete a thorough overall assessment of vulnerabilities relating to water supply, it is highly recommended that the utility establish and compare the current and projected water demand versus current and projected water supply. A means of effectively evaluate options for managing and developing reliable, adequate, and sustainable supplies of water for their customers going forward, as part of an adaption plan to climate change based on projected demand and supply is also required.

The Water Evaluation And Planning (WEAP) system which, a computer software tool developed by the Stockholm Environment Institute is a generic, water resources decision support system that can be used to integrate the biophysical resource (water availability as determined by hydro-climatology), with the human water resources extraction and consumption system that depends on it. This integration needs as a starting point an understanding of the biophysical resource, namely, an understanding of the hydrologic processes and water balance of the study area.

I order for the utility to make use of the WEAP system, the necessary resources can be downloaded from the Website: www.weap21.org/

These include the software, tutorial and user guide. The License fee for the software is waived for academic, governmental and other non-profit organizations in developing countries.

WEAP applications generally include several steps[29]. The *study definition* sets up the time frame, spatial boundary, system components and configuration of the problem. The *Current Accounts*, which can be viewed as a calibration step in the development of an application, provide a snapshot of actual water demand, pollution loads, resources and supplies for the system. Key assumptions may be built into the Current Accounts to represent policies, costs and factors that affect demand, pollution, supply and hydrology. *Scenarios* build on the Current Accounts and allow one to explore the impact of alternative assumptions or policies on future water availability and use. Finally, the scenarios are *evaluated* with regard to water sufficiency, costs and benefits, compatibility with environmental targets, and sensitivity to uncertainty in key variables.

The WEAP model as well as a Microsoft Excel spreadsheet have been used as part of a modelling exercise for three small scale water and sanitation utilities namely Masaka (Uganda), Kisii (Kenya), and Bukoba (Tanzania) in the Lake Victoria Region. The aim of the modelling exercises and report)[30] discussion is to examine how future climate and demographic scenarios in the period between years 2010 and 2050 for the Lake Victoria region of East Africa impact water utility performance within these three urban water service areas. The emphasis of the models developed for the report is aimed at showcasing how the integration of water supply and water demand with regard to future climate and demographic conditions in a single model uniquely highlight potential future operating vulnerabilities in light of climate change. With this

[29] WEAP Water Evaluation And Planning System Tutorial A collection of stand-alone modules to aid in learning the WEAP software – Stockholm Institute

[30] Climate Change Vulnerability and Infrastructure Assessment and Analysis for Small Scale Water Utilities in the Lake Victoria Basin - Vishal Mehta, Larry Dale, Omar Aslam, David Purkey

knowledge, water utility managers can better prioritize strategic responses to these vulnerabilities through targeted investments and operational best-practices.

Projections of water supply and demand from the year 2010 until 2050 were devised in light of data availability, assumptions of regional demographic trends, interviews with utility managers, and historical climate and hydrology data where available. Using these reference assumptions, action plans for the utilities are recommended and are framed within a planning context for how to best align utility management strategies to various hydrologic, demographic, and climate change scenarios.

9 DEVELOP AN ADAPTATION AND MITIGATION PLAN FOR YOUR UTILITY

The purpose of this guidebook is to enable water and wastewater utilities to develop a CC adaptation and mitigation plan based on expanding the vulnerability and risk assessment presented in the previous chapter.

This chapter will help you more fully understand the scale and nature of problems you face/will face in the future as a result of climate change. Although you may not fully realize it at present, some of the operational challenges you are confronted with could be indirectly related to the impacts of climate change that have already occurred or are being experienced at a local, regional and continental level.

Modules presented will help you as a utility further develop your assessment by:

- documenting proposed adaptation and mitigation options for each identified risk,
- Prioritizing and adopting certain options as measures to be implemented,
- Listing specific tasks to be completed for each measure,
- Identifying a relevant performance indicator (PI) with measurement unit for each measure,
- Establishing a target to be achieved in terms of the selected PI's,
- Estimating a cost to implement the proposed adaptation and mitigation measures.

Recommendations relating to further investigation and study should also be documented.

In developing your plan, it is important to bear in mind that as a WSU your *main intervention thrust* will be one of *adapting to the impacts of climate change*, rather than *mitigating* same through either the creation of energy efficiency (EE) or the use of renewable energy (RE) as an alternative energy source. Mitigation measures relating to especially EE in pumping operations should be considered.

9.1 IDENTIFY ALL POSSIBLE ADAPTATION AND MITIGATION OPTIONS

Module Objective

List all possible adaptation and mitigation options related to identified risks and vulnerabilities.

Overview

Once you have completed your vulnerability assessment and documented risks, vulnerabilities, probability (or likelihood) of occurrence, as well as current and future impacts, appropriate adaptation options that would ameliorate vulnerabilities for each risk should now be documented. Mitigation measures in the form of EE and the use of RE can be considered.

Included in the Table 9-1 and Table 9-2 below is a list of broadly defined *adaptation options* and *mitigation measures* respectively that can be considered by a WSU in formulating a CC plan. The list is not exhaustive, nor should it be considered as the only reference on this subject matter; rather it is intended to stimulate thought and discussion around adaptation measures. You may also want to more accurately define certain adaptations that are critical to your operation.

It should also be noted that adaptation options are in many instances cross-cutting in nature, where an adaptation in one area would help ameliorate the vulnerability in another area. Such adaptations can be documented under multiple risks, which would help in prioritizing them at a later stage.

Table 9-1: Broadly defined adaptation options

Impact	Broadly defined adaptation options
Water Resources	
Supply side options	Develop a contingency plan to ensure continuity of supply Use inter-basin transfers where appropriate Build desalination plants Maintain options for the development of new dams Use seasonal forecasting to design the capacity of dams, storage facilities and bulk infrastructure
Demand side options	Implement water conservation and demand management strategies Adopt the user-pays principle for the delivery of wet services Promote water re-use in all its forms Promote the use of water efficient devices Promulgate demand-side management By-laws Promote water leakage prevention
Coastal Development	
	Institute ocean edge setbacks for all seafront developments Implement best practice related to urban planning and density restrictions Acquire properties in high vulnerability areas Incorporate marginal increases in the elevation of coastal infrastructure Develop emergency evacuation plans for residents in low-lying coastal areas
Natural Water Resources	
	Preserve vulnerable coastal and inland wetlands Establish flood-lines and enforce development restrictions within flood zones Apply land-use controls especially in sensitive areas Control pollution of water resources
Infrastructure	
	Improve reactive and proactive maintenance programmes Implement an Asset Management Plan Allow for increased marginal capacity of infrastructure such as dams, pipelines, storage facilities and distribution networks to better manage both drought and flood events Relocate development away from critical infrastructure points
Storm water	
	Improve the management of storm water Construct and maintain storm water drainage and retention systems Establish flood-lines and enforce development control within flood-lines Design infrastructure to better withstand flooding Promulgate storm water By-laws
Sanitation	
	Replace out-dated and dilapidated infrastructure Reduce downtime of pump stations and treatments plants from power outages

Impact	Broadly defined adaptation options
	Remedy storm water ingress into sewerage networks Upgrade sewerage infrastructure Enforce municipal By-laws more stringently
Energy and Electrical	
	Install back-up generators at all major pumping sites Relocate electrical substations and critical plant out of floodplains
Built Environment and Urban Planning	
	Improve construction standards and specifications for especially housing developments
Disaster Management	
	Compile a Disaster Management Plan Adopt contingency planning for extreme weather events such as droughts, hurricanes, typhoons and tropical storms
Flooding	
	Relocate critical infrastructure out of floodplain Relocate informal settlements out of floodplains Improve the management of river courses Establish flood-lines along all watercourses Use best practice related to flood attenuation and storm water management
Health Related Impacts	
	Develop a heat wave emergency response strategy Develop a Water Quality Safety Plan Improve the provision of sanitation services Improve storm water management to reduce the spread of vector-borne diseases
Climate Change Driven Human Migration	
	Assist in building climate change resilience in most vulnerable countries

Table 9-2: Broadly defined Mitigation Measures

Impact	Broadly defined mitigation measures
Water Resources	
	Investigate options to use renewable energy sources such as solar, wind, wave and hydropower
Infrastructure	
	Implement energy efficiency initiatives in pumping operations
Consumer Education and Awareness	
	Promote energy efficiency at the consumer level
Sanitation	
	Implement energy efficiency measures in wastewater systems

Assignment

Based on detailed discussion and input by the CC Team, preferred adaptation measures for each identified Risk in Step 2 should be recorded under **Step 5: Planning** in **Worksheet # 4** (**Appendix A**). Thereafter specific definable tasks that would need to be undertaken for each adaptation measure should also be documented in the worksheet.

Towns that serve as a commercial hub can experience significant fluctuations in population numbers which can exert considerable demand on often already stretched water and waste water infrastructure

Picture of "Market Day" – Kisii, Kenya

9.2 PRIORITIZE AND ALIGN ADAPTATION AND MITIGATION OPTIONS TO OPERATIONAL AND INFRASTRUCTURE INVESTMENT PLANS

Module Objective

Prioritize adaptation and mitigation options (interventions) for implementation and align them to existing operational and infrastructure investment plans.

Overview

Once vulnerabilities to climate change have been assessed, impacts documented and adaptation/mitigation options proposed, it is time to select which of them will be the focus of climate change efforts in the immediate future, short-term (5 years) and if required, longer term (10 years+). You may select to address all of the listed intervention options, although available resources will in all likelihood prevent this and require you to prioritise and rank your list.

Although various theoretical approaches can be used to prioritize and evaluate the options against each other, such as benefit-cost analysis (BCA), cost-effective analysis (CEA) and multi-criteria analysis (MCA), this guidebook uses a more practical approach based on the following *criteria* for sorting, prioritizing and categorizing listed adaptation options:

- The likelihood that the problem has already occurred (Y/N)?
- The likelihood that the problem will occur in the near future (Y/N)?
- The likelihood that the problem will occur in the longer term as climate changes (Y/N)?
- Is the adaptation/mitigation an operational improvement (Y)?
- Does the adaptation/mitigation require capital investment in infrastructure (Y)?
- Will the adaptation/mitigation improve performance (Y/N)?
- Is the adaptation/mitigation a ***no regret*** or ***low regret*** solution?

These criteria have been built into the main adaptation and mitigation worksheet (a Microsoft Excel Spread-sheet) as filters, sorting tools, and priority rankings to help you in selecting, sorting and prioritizing suitable options. The criteria can be applied individually, sequentially or in any number of combinations, depending on your preferred approach. You may want to add and/or subtract criteria as you see fit.

<u>Quantitative Approach</u>

You may also want to rank or cluster the criteria according to a qualitative 'weight' used to rank the relative importance of each. By scoring each option listed in Worksheet # 4 on a scale of 1 (least importance) to 5 (most importance) and then multiplying the score by the weight assigned to each criterion, an overall score of each option can be obtained. These scores can then be used to finalize the list of options to be implemented.

<u>Qualitative Approach</u>

Should the above mechanical approach of prioritizing listed options prove to be too complicated, a less rigorous approach can be adopted by your utility involving workshops with decision makers and key stakeholders in which a more qualitative subjective approach is taken to selecting and prioritizing options from 'best' to 'worst' or 'highest' to 'lowest'. This can involve the simple scoring of each option on a scale of 1 (highest priority) to 5 (lowest priority).

It is important to understand that whatever approach is used, it should be viewed only as a *tool* to help key stakeholders in raising and debating issues, consulting with each other, and making informed decisions around the allocation of limited resources to the implementation of selected adaptation and mitigation options. **It should not take over the process but rather inform it.**

It is critical from a legitimacy point of view that stakeholders should be involved in evaluating the adaptation/mitigation options and working through each towards final selection. This process will also help stakeholders address other factors such as cost, feasibility, and impacts on other resources.

Because certain interventions will require large capital investments, they will in all likelihood need to be approved, planned for, funded, designed and implemented by a higher water authority (and worksheet # 4 can be completed in such a way so as to reflect this reality). This should not detract your utility from completing a CC plan, rather the findings of your vulnerability assessment should be used to advocate for additional funding for the required interventions.

Identify Quick Wins

For some adaptation and mitigation options, it is clear that the benefits will outweigh their costs. They are the equivalent of assessing the cost benefits of 'wearing a seatbelt' when you climb in your car. Identifying quick win adaptation/mitigation options should form part of the prioritization process and the quick wins should be prioritized for implementation, not necessarily follow the same rigorous process that may be needed in the selection and implementation of other options.

Aligning Selected Options to Existing Operational Programmes and Infrastructure Investment Plans

Many listed adaptation/mitigation options may already have been captured by your utility as either operational improvements or infrastructure investment projects. It is therefore important to undertake a process of *aligning* the CC adaptation and mitigation plan to existing plans, especially those involving medium to longer term investment in infrastructure for your utility.

Crucial to this process is to ensure that proposed new infrastructure takes into account the likely impacts of climate change, both now and in the future, to ensure CC resilience into the future. This may imply that infrastructure needs to be re-engineered in terms of capacity, size, locality, and even redesigned (if still at design stage) to a higher factor of safety, specification and construction material, to incorporate resilience.

As part of this alignment process, the following questions should be asked and answered:

Is there opportunity to incorporate adaptation/mitigation options in your current operational and capital investment planning cycle?

Usually investment in infrastructure forms part of an on-going annual planning and budgeting cycle in a WSU. Depending on where your utility is in this budgetary cycle, you may be able to integrate some of the more important and/or quick win interventions into the infrastructure investment plan for implementation in the short-term. In certain circumstances you may even be able to place some critical or emergency options on the current capital budget.

Are any of the adaptation/mitigation options included in any existing approved and funded infrastructure investment plans?

Some of the prioritized options may already form part of the approved and funded infrastructure plan for your utility, due to the identification of a problem or need under another programme. For these options it may only be necessary to ensure that the design of the proposed infrastructure incorporates resilience to the impacts of climate change.

Do any of the adaptation/mitigation options form part of existing operational improvement plans or programmes?

Some of the selected options may already form part of an operational improvement plan, having been identified as an operational risk or vulnerability under some other programme. For these options it may only be necessary to ensure that the design and installation specification incorporates resilience to the impacts of climate change.

Are there any opportunities to redesign infrastructure currently under design to accommodate CC adaptation/mitigation and improve resilience?

Some of the selected options may already have progressed to design phase under the infrastructure investment or operational improvement programme. For these options it may be necessary to re-design components in terms of capacity, size, locality, and even re-engineer same infrastructure in terms of factor of safety, specification, and construction material, to ensure resilience to the impacts of climate change.

Are the any opportunities to incorporate CC adaptation/mitigation into the construction of any infrastructure that is currently being installed?

Some options may already be under construction under another capital investment mechanism, in which opportunity to incorporate climate change resilience should be investigated.

Various tools exist internationally to assist in the costing of especially adaptation options[31].

Assignment

Rank and prioritize listed adaptation/mitigation options using a pragmatic approach that works best for your utility. Once a prioritized list of interventions has been finalized, undertake a process of aligning these options to existing asset management and infrastructure investment plans.

[31] Costing the Impacts of Climate Change in the UK: Implementation Guidelines, UKCIP, 2004

9.3 DEVELOP COMMUNICATION MATERIAL AND CUSTOMER INTERACTIVE PROGRAMME

Module Objective

Develop an awareness and education programme with dissemination material that will effectively communicate your CC plan with management, customers, employees and other stakeholders, as well as educate the general public in climate change and its impacts.

Overview

Communication around the development of your CC plan, including efforts related to what you hope to accomplish and the net positive outcome for customers of your utility is vital to the ultimate success of the programme.

A comprehensive education and awareness programme for all stakeholders should be developed as part of your utility's CC plan. This programme could include a number of components such as a media campaign, interactive workshop sessions, communiqué including newsletters, fliers, newspaper articles and updates, as well as public events. Possible partnerships with other stakeholders, government departments and the private sector should be investigated. The development of your programme should also be aligned closely with national climate change adaptation programmes.

Your programme should also provide robust information to decision-makers who will need to continually adjust the course of your CC plan. Make sure that knowledge of your CC programme is readily available and widely disseminated to especially the public. Incorporating climate change into education and training programs is also important for learners and adults alike[32].

Potential activities that you could include in your education and awareness programme targeting different audiences are provided in Table 9-3 below.

Table 9-3: Potential education and awareness programme activities

Component	Activity	Target Audience
Public Awareness	Billboards	Customer
	Wall Murals	Customer
	Celebrity Ambassadors (public appearances)	Customer
	Radio Campaign	General Public
	Launch Event	Community
Public Interaction	School Competitions	Learners
	Household Competitions	Consumers
	Fun Walk/Run	General Public
	TV Reality Show	General Public

[32] Australian National Climate Adaptation framework (2007)

Component	Activity	Target Audience
Private Sector & Institutional Consumers	Interactive Workshops	Private Sector & Institutional Consumers
	Awards for positive contribution and effort to CC Adaptation	Private Sector & Institutional Consumers
	Climate Change Scorecard & Reporting Mechanism	Private Sector & Institutional Consumers
Partner Mobilisation	Project Partnerships	Stakeholders and interest groups
Communiqué	Newsletter	Customers
	Website	General Public
	Press Releases	General Public
	Pamphlets, Flyers and Leaflets	General Public
	Public Ambassadors (non-celebrity)	General Public
	Messages and information on back of utility bill	Customers

Potential First Steps…

- Develop and implement a communications strategy to raise awareness of climate change impacts and the advantages of early attention to adaptation, including partnerships with key national professional and interest groups to develop best practice networks.
- Develop and promote tools for climate change planning tailored to user’s requirements. These could include:
  - A monthly newsletter with helpful tips that could be included in the utility account posted to all customers;
  - Decision-support tools such as methods for assessing the costs and benefits of adaptation/mitigation strategies, and guides for risk management;
  - methods for understanding social impacts;
  - a national or regional ‘one stop shop’ website where decision-makers and their advisers can access information about climate projections, likely climate change impacts, tools, guides and approaches to planning for climate change.
  - Integrate climate change into education and training for key professions, including engineering, architecture, planners, reserve managers and local government.

Development of education material and a comprehensive awareness programme forms an integral part of a successfully implemented Climate Change Plan

Picture of Schools Water Loss Education and Awareness Programme – Eastern Cape South Africa

9.4 DEVELOP AN EMERGENCY RESPONSE PLAN TO EXTREME CLIMATIC CONDITIONS SUCH AS DROUGHTS AND FLOODS

Module Objective

Develop an emergency response plan (ERP and sometimes also referred to as a disaster management plan) to enable a managed response to especially extreme climatic conditions.

Overview

When a disaster or emergency reaches such proportions that normal da-to-day operations and service delivery cannot be maintained, utility leadership would likely declare a state of emergency and request assistance from higher tiers of government. In the event that a state of emergency is declared, especially if that emergency arose because of abnormal climatic conditions, such as droughts and floods, it will be necessary for your utility to initiate extraordinary measures to deal with the many and varied crises that would rapidly unfold. These corrective measures (or responses) should as laid out in a comprehensive and up to date ERP. The ERP should outline a different response to the different types of disasters that may occur.

The ERP is a critical element of the CC plan. Most utilities have existing ERP’s in place but they do not necessarily cater for the potential disasters resulting from the effects of Climate Change. This is especially true for the predicted increase in frequency and magnitude of rainfall (which increases the likelihood of flooding) as well as droughts.

Effective emergency management relies on thorough integration of emergency plans at all levels of government and non-government involvement. Activities at each level (individual, group, community) affect the other levels. It is common to place the responsibility for governmental emergency management with the institutions for civil defence or within the conventional structure of the emergency services. However, emergency management actually starts at the lowest level and only increases to the next higher organizational level after the current level's resources have been exhausted.

The ERP should include

- Levels of emergency - To aid in determining the level of response and actions to be taken by the administration team, emergencies should be classified into levels (example: minor emergency/ major emergency/ disaster)
- Emergency response centre – centre must be suitably located and equipped to cater for the needs of the team
- Organization and responsibilities – the various departments within the team/ utility should have designated responsibilities and authority
- Emergency response team – including members from all relevant stakeholders, including civil organisations as well as the community
- Equipment for emergency response teams – personal protective equipment, rescue equipment and portable water treatment/ disinfection equipment
- Training programme to address capacity needs of the response team – identify employees to be trained and certified with the necessary competencies (to include emergency response plan training programme)
- Emergency notification procedures – Authority for notification (declaration of emergency) and methods used for alerting emergency teams and stakeholders of the emergency

- Emergency communications – channels and methods of communication
- Procedures for specific types of emergencies – ensure that a suitably qualified person develops the procedures required for the specific emergencies/ hazards (example : evacuation procedure in the event of flooding)
- Post-disaster / recovery operations – process of restoring the operations of the utility to provide water supply and sanitation services

Assignment

Develop an emergency response plan for your utility as a crucial component to the CC plan. The ERP should outline typical responses to extreme climatic conditions such as floods and droughts.

9.5 FINANCING AND CONTRACTING OPTIONS

Most utilities and water service authorities in developing countries are cash-strapped and under severe financial constraint, making the required investment in infrastructure difficult. This has a direct implication to the ability of your utility to implement adaptation and mitigation measures, most of which are capital-intensive by nature.

Module Objective

Highlight alternative sources of funding that can be secured to undertake CC adaptation/mitigation interventions.

Overview

Generally capital expenditure for infrastructure investments can be funded through a combination of:

- Grant (or public) funding made available by national, regional and local government,
- Tariffs levied for the rendering of services
- Corporate lending by commercial and development banks
- Project finance lending to special purpose vehicles which could include WSU's
- Development aid provided by international donors and agencies

It may be necessary to secure funding from different sources to implement the various adaptation and mitigation measures. All possible funding avenues should be explored with a view to securing the investment required.

Funding opportunities for especially mitigation should be pursued through the Clean Development Mechanism (CDM) of the World Bank.

Various international aid and development organizations provide grant funding for specific interventions that meet certain criteria including adaptation and mitigation. These organizations may also be willing to support fundamental climate modelling research including the establishment of weather and hydrological measuring stations.

It will however be necessary to make compelling fact-based cases of the need to implement adaptation/mitigation options based on the completed vulnerability and impact assessment. Critical to attracting funding then is the need for a structured and comprehensive CC plan.

Where income is or may be derived from carbon credits (CDM, CER's and voluntary credits) based on the implementation of accredited climate change mitigation projects (such as energy efficiency, solar heating and renewable energy initiatives), this income should be directed to support adaptation initiatives. As a first step to qualifying for carbon credits, your utility should undertake an inventory of operations that potentially contribute to carbon emissions.

Various schemes aimed at financing environmentally beneficial improvements to properties are also being piloted in many countries. Aimed at existing private residential developments, these schemes provide financial loans to homeowners to retrofit water and energy saving devices such as solar water heaters, dual-flush toilet cisterns, rainwater harvesting tanks and equipment as well as water recycling installations. Your CC plan should include some of these interventions and adaptation and mitigation options.

10 IMPLEMENTING YOUR CLIMATE CHANGE PLAN

Now that you have established benchmarks, performance indicators, undertaken and completed your Climate Change Adaptation and Mitigation Plan, it is important that you begin with the task of implementing the adaptation measures immediately. Failure to do so will be a missed opportunity to easier adaptation and mitigation options, managed water security into the future, continued service delivery and a sustainable long term future for your utility.

Implementation calls for a coordinated effort between your utility, the regional or national Water Authority and other stakeholders. Although certain processes, approvals and provision of capital intensive infrastructure may not be under your direct control or management as a utility, the CC Adaptation Team will still be able to exert substantial influence on external decision makers, especially in terms of adaptive infrastructure components that are critical to your operations and should be installed as a matter of urgency. In addition you may be able to find innovative technical and institutional solutions to some adaptive options, and thus make progress towards improving resilience.

10.1 MANAGING THE IMPLEMENTATION OF ADAPTATION OPERATIONAL IMPROVEMENTS

Module Objective

Manage the implementation of adaptation options aimed at improving operational procedures

Overview

Your greatest challenge in building resilience to climate change will more than likely be the implementation phase in which you move from plan to action.

Although many of the adaptive measures may be related to your utility's day to day operations, it is good practice to apply a *project management* approach to each task that accurately defines:

- The available approved budget for each adaptation option,
- A start and end date to implementation,
- The design and specification that will be needed during implementation,
- Resources allocated to the task
- A supervisory and quality control protocol.

For more complex projects and tasks you may need to appoint an external Contractor or Service Provider.

In managing this process the following **What**, **Who**, **When** and **How** steps should be adhered to:

1. **What** – List individual tasks and activities that will be undertaken to implement each adaptation and mitigation option
2. **Who** – Assign responsibility for both the overall adaptive/ mitigation measure (to a department or division) or for each individual tasks (to an individual staff member). Ensure good communication with either the department or individual as part of the assignment.
3. **When** – Define timelines for each task including a deadline if necessary and stress the importance that the task needs to be accomplished in a timely manner.
4. **How** – Estimate both staff time and cost to complete the task and confirm with managers that the resources are available and budgeted for. If there are other direct costs that will be incurred (hire of plant, materials, service providers), these need to be quantified and confirmation provided that they are included in budgetary amounts.

Worksheet # 5 in Table 10-1 below is designed to provide you with a template to assist you in this process.

Table 10-1: Worksheet # 5: Adaptation and Mitigation Measures

Worksheet # 5				
Adaptation/ Mitigation Measure:				
Task	**Resource**	**Timeline**	**Level of Effort (Estimated - hours)**	**Estimated Cost**
Task: Deliverable:		Start: End:		
Task: Deliverable:		Start: End:		
Task: Deliverable:		Start: End:		
Task: Deliverable:		Start: End:		
Task: Deliverable:		Start: End:		
Task: Deliverable:		Start: End:		
Task: Deliverable:		Start: End:		

10.2 REVIEW PROGRESS IN IMPLEMENTING ADAPTATION AND MITIGATION OPTIONS

Module Objective

Develop a plan for regular, periodic reviews of progress in implementing each adaptation or mitigation measure.

Overview

Regular periodic reviews relating to the implementation of your CC Adaptation and Mitigation Plan should be undertaken. This will help you obtain an overall picture of progress relative to your plan, performance indicators and targets.

In developing a review protocol, consideration should be given to the following:

- How often the review should be conducted
- How progress is measured
- Who is responsible for reporting and compiling the review
- What further action needs to be taken

A sample review protocol would be:

- Review your progress monthly including progress meetings with key resources
- Status and progress of each adaptive measure should be reported on by assigned staff
- Performance indicators should be updated and progress towards stated targets assessed
- Use the outcome of the review to complete the scorecard (Table 10-2” Worksheet # 6) below
- Identify next steps and corrective actions if any

Table 10-2: Worksheet # 6 : Adaptation and Mitigation Options

Worksheet # 6	
Adaptation/ Mitigation Option:	
Parameter	**Status**
Target for FY10	
Status as at________________	
Tasks Identified	
Tasks Accomplished	

Worksheet # 6	
Adaptation/ Mitigation Option:	
Parameter	**Status**
Observations	
Corrective Actions Needed	
Next Steps	
Review completed by:	

If the progress review shows that your utility is not performing and not progressing towards implementation of adaptive measures and achievement of targets, reasons for non performance should be established and corrective action decided on and implemented.

Ask the following questions:

- Did something change during the review period?
- Was the target realistic?
- Were the identified tasks sufficient to achieve the target?
- Were some tasks not completed?

Based on the answers to these questions, corrective action can be proposed and taken. If necessary, review your target, methodology and general approach to something that may be more realistic given the privilege of hindsight.

10.3 TRAIN STAFF IN CC ASSESSMENT, ADAPTATION AND MITIGATION

Module Objective

Build capacity within the utility to address the challenges of climate change.

Overview

The success of your utility in addressing the impact of climate change, will to a large extent depend on the successful development of the necessary capacity within the organisation. While external resources can be procured to implement or assist in the implementation of the programme, including the climate change vulnerability assessment and adaptation and mitigation plan, it is strongly recommended that capacity is developed and maintained within your utility.

The Module presented in **Chapter 7.3** describes the process of putting together a CC Team and Programme Leadership is discussed. In this section, guidance is given on the training of this team as well as your utility as a whole. The reason for this approach is that a culture shift is required within the organisation to ensure that climate change (in particular the vulnerability assessment) is included in all future planning processes.

The recommended approach is that this guidebook as well as the references provided, be used as basis for the training material. Copies of the guidebook and the required reference materials should be made available to the staff both in hard copy format as well as PDF for those who have access to computers.

The team should be taken through the process as outlined in the guidebook. The process provided in this guidebook, as shown in Figure 10-1 below should be repeated on a regular basis (preferably annually). The training in response to the process should also be updated as a consequence of this annual revision.

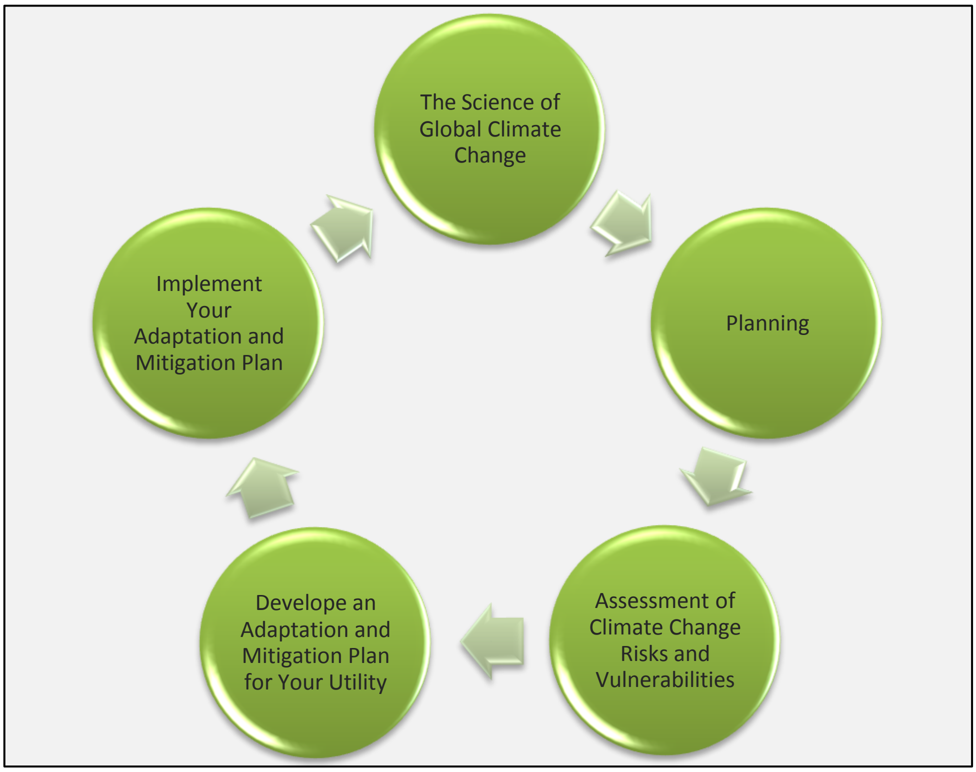


Figure 10-1: Guidebook approach to Training on Climate Change

Tip: *The section science of climate change in the Guidebook should be reviewed on a regular basis as more recent studies and models, both on a global (IPCC) and on a regional level become available. Any changes in the climate forecasts for the region and the potential impact of these changes can then be taken into consideration in annual review process, beginning with planning and the assessment of climate change risks and vulnerabilities.*

Dealing with Climate Change should become an integral part of the utilities day to day operations. This can be achieved through a training programme aimed at capacitating staff on climate change.

Picture of Presentation of Climate Change Guidebook to BUWASA – Bukoba, Tanzania

10.4 MEASURE, MONITOR AND VERIFY BENCHMARKING INDICATORS

Module Objective

How to implement performance monitoring against selected benchmarks when implementing your Climate Change Plan.

Overview

The Module presented in **Chapter 7.7** provides an overview of selecting benchmarks and KPI's relating to these benchmarks. Having identified these benchmarks and KPI's it is necessary to measure the performance of your utility against these benchmarks. These measurements should be carried out regularly as a planned activity that enables you to monitor your progress and achievements and identify where insufficient progress is being made so that remedial action can be taken.

An example Worksheet to be used in recording and evaluating the performance in terms of the benchmarking indicators is provided in Table 10-3 below. The worksheet is completed for each monitoring period. Benchmarks adopted for each adaptation and mitigation option having been established are recorded as the baseline. At the end of the monitoring period, the measurements for the period should be carried out and recorded together with the date at which the measurement was taken. A revue of the performance is then undertaken and the target indicator is adjusted or remains the same. In order to encourage a process of continual development, a new target can be set which is an improvement of the previous benchmark target. Comments relating to important factors that influenced performance during the measurement period are also recorded in the last column of the worksheet.

In summary, the following factors should be considered when implementing performance monitoring:

- Ensure that the benchmarks you have selected are aligned with the objectives of your adaptation and mitigation plan and your utilities strategic objectives
- Targets should be adopted and revised by the relevant stakeholders as well as your Climate Change Team
- Set targets/ target revisions that are realistic and encourage your staff to work towards achieving them
- Make sure that revised targets are communicated to your departments that are responsible for the operations who's performance impacts upon the measurements
- Measure early and often so that corrective actions can be made to improve performance timeously

Tip: *It is important to include behaviour-based targets for adaptation options as they may not necessarily result in the biggest gains in performance but are very important in terms of achieving a culture change (towards CC) in your utility.*

Table 10-3: Worksheet # 7: Evaluation Sheet for Benchmarks applicable to Adaptation Measures

Worksheet # 7:								
No.	**Adaptation/ Mitigation Option**	**Benchmark/ KPI**	**Baseline**	**Target**	**Measurement**	**Measurement Date**	**Revised Target**	**Comments**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

11 CONCLUSION

Developing and implementing a CC plan makes sound business, environmental, managerial and technical sense. It will greatly assist your utility in dealing with current and future vulnerabilities linked to climatic conditions and weather variations, which are predicted to lead to increased precipitation, evaporation, sea level and surface temperatures, deteriorating surface water quality as well as increased intensity and occurrence of floods and droughts.

Besides improved resilience to climate change, additional benefits that will accrue from the adaptive/ mitigative process include:

- Improved ability to deliver water and wastewater services
- Reduced operating costs in the longer term
- Improved attractiveness for investment by donor and development agencies
- Improved planning for the provision of infrastructure
- Improved capacity to extend services to the urban poor
- A healthier and more productive community
- Improved capacity for disaster management
- Secured infrastructure investments into the future

Climate Change planning and implementation are iterative processes and should be seen as such, with the process being reviewed on an annual basis, in line with normal budgetary and planning procedures.

There is no better time to start than now! You are encouraged to be proactive, take the lead by initiating the CC planning process in your utility. This guidebook, worksheets and listed resources will greatly assist you in initiating, structuring, organizing, drafting and finalizing your plan, as well as provide overall guidance during the implementation of the prioritized intervention measures.

The end result will be a water and sanitation utility that is more resilient to the pending impacts of a changing global, regional and local climate.

Should you require any further assistance, the Authors of this guidebook can be contacted at www.re-solve.co.za

12 RESOURCES, ASSISTANCE AND TOOLS

Definition by the IPCC http//www.ipcc.ch/pub/syrgloss.pdf

Urbanization and Environmental Challenges in Asia/Pacific, Middle East and Africa – Ranking of Worldwide Centers of Commerce.

Climate Change Vulnerability and Infrastructure Assessment and Analysis for Small Scale Water Utilities in the Lake Victoria Basin, 30 July 2010 – *Omar Aslam. Larry Dale, Vishal Mehta, Normal Miller.*

James Hansen, Makiko Sato, Reto Ruedy, Ken Lo, David Lea, & Martin Medina-Elizade, "Global Temperature Change," Proceedings of the National Academy of Sciences, Vol. 103 no. 39, pp. 14288-14293, September 2006.

IPCC, "Climate Change 2007: The Physical Science Basis," *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, IPCC Secretariat, Geneva, Switzerland, 2007.

Nicholson, S.E., 1981: The Historical Climatology of Africa . Climate and History T.M.L. Wigley, M.J. Ingram, G. Farmer, eds., Cambridge Press, 249-270.

M. Pascual, J. A. Ahumada, L. F. Chaves, X. Rodó, and M. Bouma, "Malaria resurgence in the East African highlands: Temperature trends revisited," Proc Natl Acad Sci U S A. 2006 April 11; 103(15): 5829–5834.

S. E. Nicholson, "A Review of Climate Dynamics and Climate Variability in Eastern Africa," *The limnology, climatology and paleoclimatology of the East African lakes* (T.C. Johnson and E. Odada, eds.), Gordon and Breach, Amsterdam , 1996, 25-56.

Water levels are based on the station gage in Jinja, Uganda (mouth of Victoria Nile), Nicholson, S. E., and X. Yin, 1998: Variations of African lakes during the last two centuries. In Water resources variability in Africa during the XXth Century, E. Servat, D. Hughes, J.-M;. Fritsch and M. Hulme, eds., IAHS Press,Wallingford, UK, 181-188.

IPCC, 2007.

IPCC, "Special Report on Emission Scenarios,"2007.

IPCC, 4th Assessment Report 2007.

Meehl, G.A., and W.M. Washington, 1996: "El Nino-like climate change in a model with increased atmospheric CO2 concentrations," Nature, 382, 56--60.

J. V. Sutcliffe and G. Petersen, "Lake Victoria: derivation of a corrected natural water level series," *Hydrological Sciences Journal*, Vol. 52, No. 6, December 2007, pages 1316 – 1321, 2007.

Norman L. Miller and Nicole J. Schlegel, "Analysis of Climate Change in the Lake Victoria Region" Unpublished Draft, 2010.

Nicholson SE. "Historical and modern fluctuations of lakes Tanganyika and Rukwa and their relationship to rainfall variability," *Climatic Change*. 1999;41:53–71.

Yin X, Nicholson SE. "Interpreting annual rainfall from the level of Lake Victoria," Journal of Hydrometeorology, 2002;3:406–416.

Marchant R, Mumbi C, Behera S, Yamagata T. "The Indian Ocean dipole – the unsung driver of climatic variability in East Africa," African Journal of Ecology, 2006;45:4–16.

Sutcliffe JV, Petersen G. "Lake Victoria: derivation of a corrected natural water level series," Hydrological Science 2007;52:1316–1321.

A Compendium of Best Practices in Water Infrastructure Asset Management: JN Bhagwan: Global Water Research Coalition, 2009

Performance Indicators for Water Supply Services, Manual of Best Practice: Alegre, H. , Hirner, W.,Baptista, J. and Parena, R.: International Water Association, 2000 – IWA Publishing

Performance Indicators for Wastewater Services: Matos, R., Cardoso, A., Ashley, R., Duarte, P., Molinari, A., Schulz, A.: International Water Association, – 2003 IWA Publishing

Costing the Impacts of Climate Change in the UK: Implementation Guidelines, UKCIP, 2004

Climate Change and Urban Water Utilities: Challenges & Opportunities - published by the Water Sector Board of the Sustainable Development Network of the World Bank

Performance Indicators for Water Supply Services, Manual of Best Practice: Alegre, H. , Hirner, W.,Baptista, J. and Parena, R.: International Water Association, 2000

Performance Indicators for Wastewater Services – 2003 IWA Publishing
Water Safety Plan, Step-by-step risk management for drinking-water suppliers – WHO, IWA
WEAP Water Evaluation And Planning System Tutorial A collection of stand-alone modules to aid in learning the WEAP software – Stockholm Institute
Climate Change Vulnerability and Infrastructure Assessment and Analysis for Small Scale Water Utilities in the Lake Victoria Basin - Vishal Mehta, Larry Dale, Omar Aslam, David Purkey
Costing the Impacts of Climate Change in the UK: Implementation Guidelines, UKCIP, 2004
Australian National Climate Adaptation framework (2007)

APPENDIX A: Worksheets # 1 – 7

APPENDIX B: Benchmarks and Performance Indicators

APPENDIX C: Preliminary Readiness Assessment Spreadsheet

UN-HABITAT
FOR A BETTER URBAN FUTURE

Robert Goodwin
Unit Leader, Water and Sanitation
Urban Basic Services Branch
UN-HABITAT
PO Box 30030, Nairobi 00100, Kenya
Tel: (+254)-207624910
E-mail: robert.goodwin@unhabitat.org