How to Climate Proof Water & Sanitation Services for the Urban Poor

Executive Summary

Climate change has many uncertainties, but in general we can expect increases in temperatures, the intensity of precipitation, storms, droughts and extreme events; changes in average precipitation are less certain but will become more erratic, shifting in season. For water and sanitation providers climate change will tend to exacerbate or relieve existing vulnerabilities rather than creating new issues. The impact on individual projects depends upon their particular vulnerabilities. To adapt, water and sanitation providers need to increase the robustness of their systems by assessing the impacts across multiple scenarios. Populations will be impacted by climate change in other ways too and this may affect their ability to access water and sanitation services. The impacts must be considered within the context of population growth, urbanisation and environmental degradation. For providers, the most pragmatic approach is to ensure resilience to environmental change and preparedness for disasters.

Tom Heath, Alison Parker & Keith Weatherhead, 2010

WSUP Water & Sanitation for the Urban Poor

Cranfield University

INTRODUCTION

This report is based upon a 10 month project assessing the vulnerability of WSUP (Water and Sanitation for the Urban Poor) projects to climate change, converting climate change predictions into recommended adaptations. The findings are based on a literature review and field work in Kenya, Madagascar and Zambia, undertaking focus groups, stakeholder interviews and observations. This report synthesises the science of climate change, the impacts of climate change on drinking water and sanitation, how to climate proof water and sanitation services and how to adapt:

Climate Change Science

There is an abundance of reports and forums on climate change and water. However, most present similar information and recommendations based on common sources. The majority focus on the regional and national level with few addressing the project level or specifics for water and sanitation services. Two of the most pragmatic reports are an assessment of resilience (Vision 2030) undertaken by DFID and the WHO[1], and ongoing work by the IRC[2] on adaptation of water sanitation and hygiene services delivery. The main aspects relevant to water and climate change are:

- The scientific community widely accept that climate change is a reality[3]. The Inter governmental Panel on Climate Change (IPCC) has concluded that human activities are altering our climate system and will continue to do so[4]. Figure 2 summarises the process and threats of climate change
- Air temperature and potential evaporation are projected to increase globally (there is less certainty for actual evaporation); precipitation is projected to increase, but the changes vary geographically and temporally (increasing at high latitudes; but uncertain at low latitudes [4]); global sea level is expected to rise by 0.18 m to 0.59 m by the end of the century[5]
- Climate changes may occur as one of three climate change trajectories (Figure 1):
    - A gradual change in "mean" climate;
    - Changes in the degree of climate variability around some mean value (e.g. increasing frequency and degree of extreme weather events);
    - "Modal" change in climate (shift from relative stability to rapid[6] change e.g. melting of a glacier).

  The 2 latter projections are very difficult to model[5]
- Warming of the atmosphere and ocean will change major weather systems, which will alter the temporal and spatial patterns of rainfall. There will be consequences for runoff, surface water and groundwater[4]
- Water is the primary medium through which climate change will influence the Earth's ecosystems, affecting food availability, utilisation and the livelihoods and well-being of societies[7]
- Climate change is expected to exacerbate current stresses on water resources from population growth, urbanisation and economic and land-use change[8]. For example water stress will increase due to increases in physical scarcity and economic and social scarcity driven by changes in demand for water[6]
- Problems with water resource management impacts hamper economic performance and increases poverty[9]
- Globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits[4]

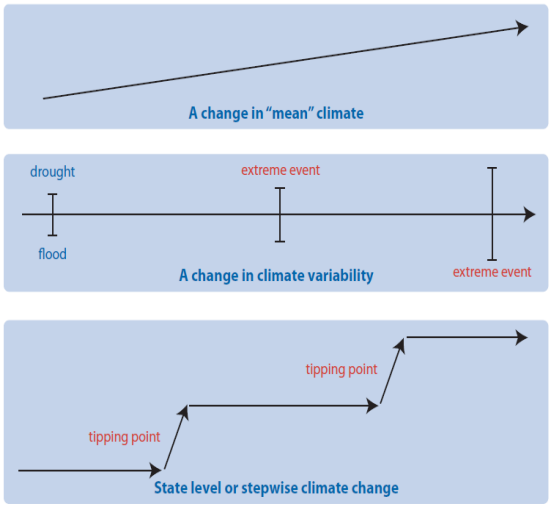

Figure 1: Climate Change Trajectories[5]

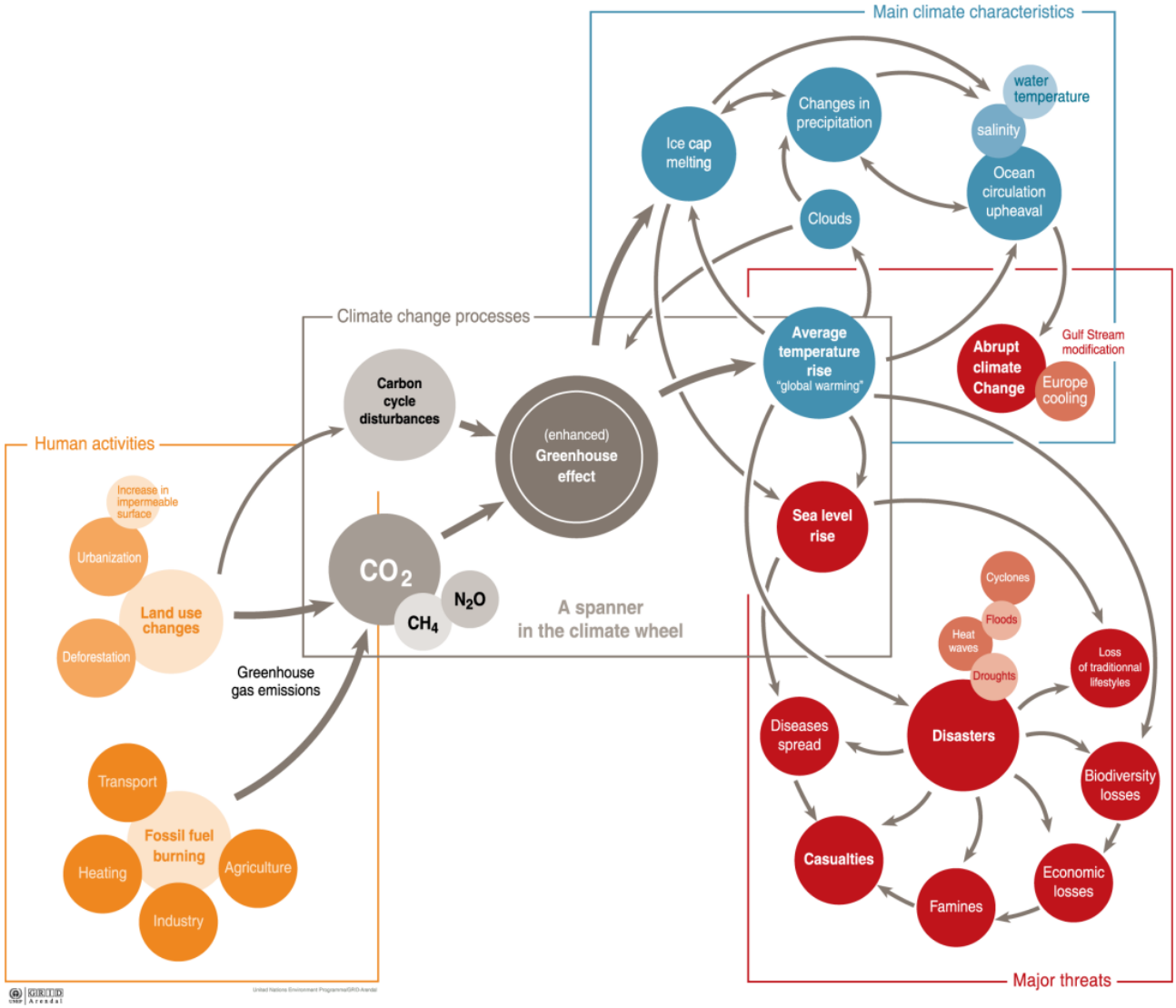

Figure 2: Climate change: processes, characteristics and threats[10]

Uncertainty and Context

"One thing is certain; under climate change uncertainty will increase[8]"

When making climate change impact assessments, a 'cascade' of uncertainty arises, making it difficult to make reliable predictions[8]. For example individual results vary in both magnitude and scale depending on the scenario and global climate model used. However, the main uncertainties are not from inadequate scientific understanding, but from social and economic factors. Therefore climate change must be considered within the context of current population growth, unplanned urbanisation, future strife and/or wars and existing environmental vulnerabilities. Even without anthropogenic climate change, climate variability undermines food security, negatively affects the environment and significantly impacts livelihoods.

Previous Studies on the Impact on Drinking Water Supply and Sanitation

Water is at the root of a complex vulnerability dynamic, which is intensified by climate change impacting the hydrological cycle affecting water supplies, river flows and groundwater[9]. For drinking water and sanitation, the affects are realised through floods, water shortages (droughts), increases in rainfall intensity, changes to the seasons, decreased water quality and less predictable weather, which makes it difficult to manage water resources and affects the function and operation of existing water infrastructure. There will also be opportunities associated with climate change, for example, increases in rainfall in arid

regions or rainfall reductions in flood prone areas. But, positive impacts are uncertain, and in general drier regions will become drier and wetter regions wetter. Vision 2030 (2010) analysed the vulnerability and adaptive capacity of improved water and sanitation technologies (as defined by the WHO) and management approaches to three rainfall scenarios (increasing/decreasing rainfall and increasing rainfall intensity)[1]. The work was based on background studies of resilience, climate forecasts and interviews. The impact on water resources and water and sanitation technologies is defined in Table 1.

Table 1: Summary of the impacts on water resources and water supply and sanitation facilities of each climate scenario[1]

Rainfall Scenario	Impacts on water resources	Impact on water supply and sanitation facilities
Increased amount of rainfall	- Increased frequency of flooding - Deterioration of water quality - Increased groundwater recharge and rising groundwater levels	- Damage to both water supply and sanitation facilities - Flooding of sanitation systems resulting in contaminated flood waters which further contaminate the water supply and distribution system - Ingress of groundwater into pipe networks, septic tanks and pit latrines - Increased transport of contamination in soils and aquifers
Decreased amount of rainfall	- Falling groundwater levels - Low surface water volumes - Deterioration of water quality - Changes compounded by increased temperatures and evapotranspiration	- Salinity of groundwater increases - Sewage in rivers becomes less diluted decreasing water quality - Increased algal growth - Insufficient water makes flush-sanitation systems redundant
Increased intensity of rainfall	- Changes in groundwater recharge - More run-off resulting in more erosion and greater transport of contaminants to surface water - Flash flooding - Deterioration of water quality	- Increased turbidity resulting in requirement for better sedimentation and filtration in surface water treatment plants - Damage to both water supply and sanitation infrastructure from flash flooding

Vision 2030 also assessed the resilience of technologies to each rainfall scenarios[1] (Figure 4). The resilience was categorised as high (resilient to most possible climate changes), medium (resilient to a significant number of possible climate changes) and low (resilient to a restricted number of climate changes). This information enables organisations to overview the resilience of their infrastructure to the different scenarios. By understanding the current resilience, water and sanitation providers can identify the technologies which are most vulnerable and what the affects will be using the Vision 2040 technical reports[11].

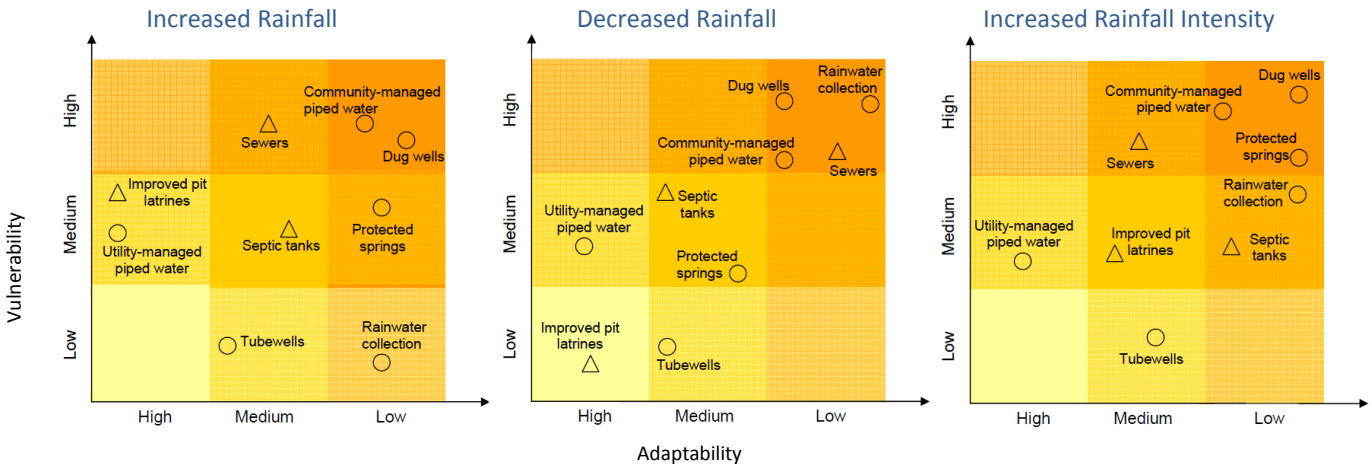

Figure 4: Resilience of water and sanitation technolies[1]

THE IMPACT OF CLIMATE CHANGE ON LOW-INCOME URBAN COMMUNITIES

The impact of climate change was assessed in three cities where WSUP works (Antananarivo[12], Lusaka[13], and Naivasha[14]) through a series of field visits involving observations, key informant and community interviews. Using the climate change predictions for the country, rainfall scenarios were identified for each city and the impact on the hydrological cycle determined. This was one of the most uncertain aspects of the vulnerability assessment. For example, in Naivasha despite there only being one rainfall scenario (decreasing rainfall) two scenarios linked to the lake levels were assessed to account for uncertainties associated with runoff and infiltration,. Once the impacts were estimated, it was possible to identify the vulnerabilities using Vision 2030.

Table 2: Summary of the climate scenarios assessed for the three cities and the impacts on the low income areas

	Lusaka - Zambia	Naivasha - Kenya	Antananarivo - Madagascar
Climate Scenarios	**2 Scenarios:** **- Increased rainfall and rainfall intensity:** Increase in river flow, groundwater levels and localised flooding **- Decreased rainfall and rainfall intensity:** Decrease in water table and river levels. Increase in groundwater abstractions, increased irrigation abstraction from river, decrease in river's water quality	**1 Scenario:** **- Decreased rainfall and increased rainfall intensity, but 2 lake scenarios*:** **- Increased lake levels:** Increase in rainfall intensity in the upper catchment results in increased runoff and river flow, offsetting the increase in evaporation at the lake, maintaining the lake level **- Decreased lake levels:** Significant increases in evaporation from the lake (and irrigation demand); rainfall decreases and is more sporadic offsetting the increase in intensity and runoff	**1 Scenario:** **- Increased rainfall and rainfall intensity:** Increase in runoff and river levels in the upper catchment, river is more flashy and water table rises. Reduction in number of days drains can gravity drain to river. Result is an increase in the frequency of riverine flooding and inundation from the drains
Imnact on Peri-Urban and Informal Areas	**Increasing Precipitation:** Kanyama is most at risk to an increase in precipitation, resulting in an increase in flooding (currently Kanyama's floods last for 3 months). Flooding causes kiosks and buildings to collapse, contaminates water supplies (particularly the shallow wells used in the unserved areas) and affects livelihoods, education and health. Flooded latrines and contaminated water will increase cholera and diarrhoea. In Chazanga there will be flood damage to boreholes, kiosks, septic tanks and pit latrines and poor drainage at kiosks. **Decreasing Precipitation:** Chazanga is most at risk to a decrease in precipitation which will lead to a lower water table. This will result in water scarcity, damage to infrastructure and drying up of shallow wells, all of which will increase the demand for new kiosks. In addition, decreased rainfall will affect hydroelectricity generation and cause power shortages. There will be a positive impact on Kanyama, as it will reduce the risk of the drains flooding and lower the water table. However there will be more migration exacerbating land pressures	**Decreasing lake and ground waters** will have a significant impact as there will be higher domestic demand whilst surface water availability decreases. During droughts there are longer queues, water from vendors is more expensive and it takes longer to collect. As a result, water use decreases, hygiene deteriorates and disease increases. The lake area reduces and there is increased conflict between pastoralists and farmers; tourism and fishing suffers, there is reduced employment (in particular from the flower and vegetable farms as they are less profitable to run) and the lake's quality deteriorates. The main problems cited by the community during previous droughts were a decrease in income and the increased cost of food and water. There was little impact on the borehole supply (as it is a confined aquifer) and latrines **Increasing lake and groundwater levels** is largely positive for Naivasha as there is more water for domestic and irrigation use. The main problem is an increase in the number and intensity of flash floods. This increases the amount of garbage and silt washed into the lake, causes latrines to collapse and overflow, exposes pipes, damages houses and crops and inundates roads which disrupt local business. However, flash floods are only an inconvenience to the community as they are able to harvest the increase in rainwater, but there is an observable increase in disease	**Increase in flooding (river and drains):** In the informal areas there will be an increase in the frequency and severity of flooding from the drains. This presents major health risks and disrupts the lives of communities. Water will get into houses, employment will decrease, it will be more difficult to travel, food costs will increase and the environment becomes dirty, odorous and very unpleasant. The infrastructure installed by CARE, WSUP and WaterAid is resilient to flooding, but the water supplied by JIRAMA is contaminated during floods as the catchment isn't protected, increased run-off leads to soil erosion giving the water a high sediment load and there is high non revenue water. In addition, household latrines overflow, their superstructures collapse, flying toilets increase (as latrines are flooded), there are long queues at kiosks, taps are submerged and the water pressure is lower. Peri-Urban areas: In the uplands they will experience an increase in surface runoff, while the lowlands and paddies will flood from drains. Areas near the river will also flood. The impacts are similar to the informal areas but there will also be damage to crops and livestock, whilst opportunities for alternative employment will decrease. However, in the per-urban areas there is typically more space to implement local coping mechanisms. When the paddies flood the water will take longer to drain due to higher groundwater.

* In Naivasha the scenarios are based around lake levels due to uncertainties with rainfall and evaporation and the affect on infiltration and runoff

In the three cities assessed, eleven communities were visited of which eight were vulnerable to flooding and four to water shortages. The impacts of the rainfall change upon areas at risk of flooding and drought were very similar across all three cities. Figure 3 summarises these, indicating that climate change won't always be negative and for certain scenarios, it will have a positive impact on communities (e.g. increased rainwater harvesting associated with increased rainfall). However, in most cases the negative aspects will be more significant.

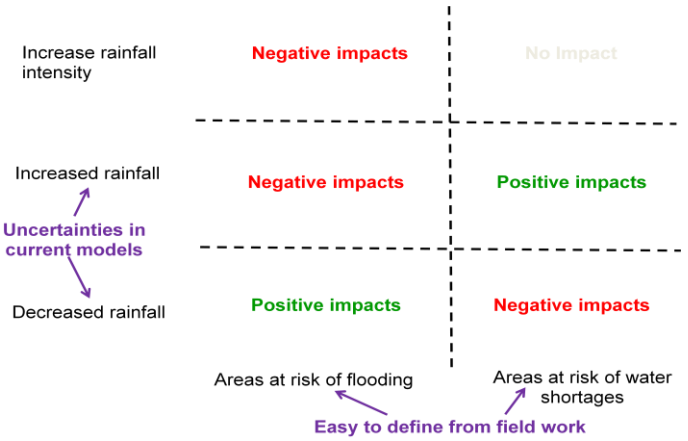

Figure 3: Impacts of climate change on flood and drought prone areas

The impacts on drought and flood prone areas can be divided into regional and local scales and are detailed in Table 3. Regional impacts are more significant, as they affect more people, require more finance and need intervention from governments and other institutions. For example, during a regional drought food shortages impact everyone, reducing available incomes. The main differences between the cities arose from the impacts of climate change on other sectors, which stressed existing systems. For example, droughts affect food prices, hydroelectric production and increase the demand for water, which is combined with reduced employment and an increase in the cost of consumables, especially charcoal and staple food crops (e.g. maize or rice). Climate change also affects the management and governance of water providers, as resources will be strained - increasing conflict over allocation and access.

Table 3: Impacts on the low-income areas

	Flooding	Droughts
Local	**Localised: If drainage capacity is inadequate:** - Latrines overflow - Roads damaged/impassable increasing the cost of charcoal and food - Pipes exposed - Siltation of water resources - Latrines/buildings collapse - Water in houses - Disease increases especially malaria, dysentery and diarrhoea[15] - Solid waste dispersed - Employment deceases - Taps submerged - Income generating activity decreased - Contamination of boreholes	- Water shortages - Water cost increases - Livestock suffer - Crops destroyed - Less water for health and hygiene - Long queues at kiosks/borehole - Increased poverty - Education suffers (less money for school fees) - Malnutrition - Health issues - Water pressure drops
Regional	**River: If riverine flood defences are breached:** - All the above factors plus: - Crops damaged - Road network damaged - Drowning - Infrastructure damage - Increased treatment costs	- Hydroelectric shortages - Water bodies dry up - Food insecurity – food costs increase - Increased conflict

IS CLIMATE CHANGE RELEVANT

"If a project is sensitive to climate variability, it is likely to be sensitive to climate change[16]"

Every project should assess whether climate variability or change could compromise the integrity, effectiveness, or longevity of the project within the planning horizon for the project. USAID[16] outline a process for assessing the vulnerability of a project, based on the project cycle, which can be utilised for standalone projects or incorporated into existing projects (Figure 5 outlines the steps). If a project is supported by USAID their Global Climate Change team[17] may assist in the assessment. During this study the USAID [ActionAid[18] and Cristal[19]] methodologies were adapted to focus upon water and sanitation. First a rapid screening process should be undertaken by project staff, to determine if the project is vulnerable to climate change. The screening process is outlined below. If this indicates the project is sensitive to climate then a more in depth analysis should be undertaken. This needs to be tendered to an organisation with climatic, hydrological and social data gathering experience, with knowledge of the area; terms of reference have been prepared[20]. Alternatively, if the project team have a clear understanding of the vulnerabilities, appropriate adaptation can be identified internally (further guidance is provided in TOR Guide[21]).

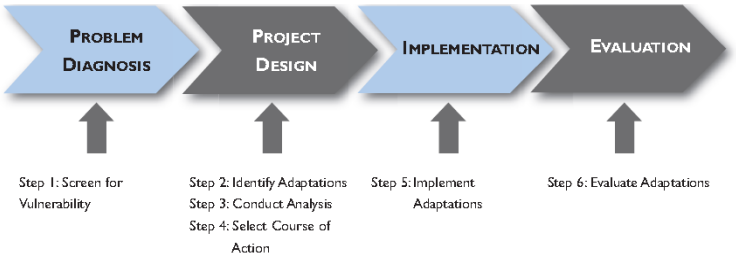

Figure 5 Climate change vulnerability and adaption process

Rapid Screening Process:

1. Collect Resources (details in TOR guide[21])
   - Read the countries National Action Plan for Adaptation[22]
   - Read UNEP climate change profile[23]
   - Read the countries national communications to the UNFCCC[24]
   - Download Earthscan and FAO AQUASTAT data sheets[25]
   - Determine current understanding of climate change (contact or search for documents prepared by Meteorological or Climate Change departments/organisations)

2. Assess Significance of Climate Change
   1. Discern the projected change to climate (precipitation, temperature and extreme events)
   2. Develop a set of plausible (although not necessarily equally likely) scenarios based on the three rainfall scenarios that describe different futures (recognising the future is not necessarily like the past[4]), ideally encompassing the range of possible changes
   3. Estimate the impact on the hydrological cycle of each scenario, in particular changes to runoff/infiltration
   4. Use vulnerability and risk assessments to gauge the potential impact of climate change on:
      - The country as a whole and the sectors not directly related to water and sanitation and how they will impact water and sanitation systems (including the impact on vulnerable sectors, agriculture and livelihoods)
      - The water resources and water supply (review what the main utilities and regulators are planning for future water supply; in particular changes in demand, quality and variability)
      - The project, assessing the impact on supply, demand, livelihoods and the community
      - Water and sanitation technologies (reviewing the resilience of each technology)

3. Plan Adaptations
   A. If impacts are understood and significant – plan adaptations and mitigation measures; guidance is available in TOR notes[21] and USAID guide[17], otherwise tender impact assessment.
   B. If impacts are unknown or unclear– tender impact assessment
   C. If Impacts are understood but not significant – keep aware of updates to forecasting and impact assessments

CLIMATE CHANGE ADAPTATION

"Responses to climate change must focus on water"[7]

Adapting to climate change requires a combination of technological and managerial measures, and capacity building to increase the robustness of systems. Coping with climate change does not involve many entirely new processes or techniques. It should, however, be made clear that this is not an argument for 'business as usual' and climate change adaptations should not simply be 'bolted on' to existing plans. Instead they need to be properly assessed, as future long term changes can introduce new unexpected risks to projects[17]. In particular, changes to extremes (changes to climate trajectories – Figure 2) and risks arising from an increase in rainfall intensity should be considered. These are conditions which may not be a current risk, but predicted increases in intensity will increase runoff, nutrient pathways and localised flooding (often of highly contaminated water).

Water providers should not consider climate change in isolation, but rank and prioritise it against other sources of risks and uncertainty, focusing on increasing the environmental resilience and disaster preparedness of projects[26]. In general, for projects where there is a clear understanding of environmental issues and how to mitigate them (for example, flooding in Antananarivo), climate proofing will be less urgent as strategies addressing these will lower the climate change risk. However, climate proofing will still be applicable and necessary to identify potential new risks and priorities for action. In particular, when rainfall trends reverse or there are dramatic changes predicted (e.g. rainfall that is currently increasing is predicted to decrease), the impacts should be reviewed anew.

When planning adaptations to the various scenarios identified, it's helpful to refer to Vision 2030, as it provides a comprehensive overview of the vulnerabilities and adaptations associated with the different impacts for various WASH technologies. The most pragmatic adaptation is to develop the resilience of water and sanitation systems – managing risks, building their capacity to deal with unpredictable events and prioritising no-regret measures[9]. These recommendations should be incorporated within a Water Safety Plan, incorporating any other issues and using it as a framework to reduce risks to drinking water from catchment to consumer[27]. The adaptations for Antananarivo, Lusaka and Naivasha were specific to each city, but there were common adaptations which addressed the risk of droughts and flooding, detailed in Table 4.

Table 4 Common adaptations for areas at risk to flooding or drought

	Risk of Water Shortages (droughts)	**Risk of Floods**
Local Service Provider	- Ensure affordable and accessible water supply - Expand kiosk network into unserved areas - Investigate alternative supplies to use during droughts - Community education and hygiene promotion on the risks to health during droughts	- Community education and hygiene promotion on the risks associated with floods - Education on best practice for latrine construction to prevent latrine collapse and overflowing - Protect boreholes and pipe network from flooding - Regular sanitary inspections during floods - Tighter enforcement against fly tipping - Chlorinate water supply during floods
Utility	- Support the expansion of new kiosks - Build new storage tanks - Investigate the recharge rate/sustainable yield of aquifers	- Leak detection and pipe maintenance - Reduce illegal connections and improve the hydrostatic pressure - Monitoring water quality during floods - Regular inspection of infrastructure during floods
Council	- Engage in water allocation dialogues	- Improve drainage systems: clear and maintain drains, legislation against dumping - Improve solid waste collection - Subsidise tanker/waste disposal options - Land management activities to reduce severity of floods

Beyond the project level, adaptations need to be considered at the governance level, as effective adaptation requires a strengthened planning and implementation process[2]. Governance adaptations identified to adapt to climate change are[7]:

- Mainstream adaptations within the broader development context;
- Strengthen governance and improve water management;
- Improve and share knowledge and information on climate and adaptation measures, and invest in data collection;
- Build long-term resilience through stronger institutions, and invest in infrastructure and in well functioning ecosystems;
- Invest in cost-effective and adaptive water management as well as technology transfers;
- Leverage additional funds through both increased national budgetary allocations and innovative funding mechanisms for adaptation in water management.

TEARFUND[28] identify a 4 step process for incorporating climate change at the policy level which entails:

1. establishing an understanding of the climate risks and key actors;
2. strengthening national policy frameworks;
3. developing and implementing a climate resilient action plan for the water sector;
4. tracking performance and adjusting plans.

In addition, the Water Integrity Network[29] raised concerns about management of future flows of money into the sector and potential corruption. Finally, water providers need to be aware of their carbon emissions, principally the energy required for pumping and should consider alternative energy sources.

FUNDING

At the project level adaptation to climate change will require additional funding; however, increasing the environmental resilience will positively impact other aspects of the project, improving its sustainability. The funding should be drawn from environmental or management budgets, alternatively new funding can be sourced. Presently the donor community is enthusiastic for funding climate change adaptations, but little money is available from national governments. Typically in developing countries there is limited awareness of climate change outside government (Table 5). Adapting to climate change has clear benefits and the initial investments make sense when considered within projects lifetime as they ensure the' effective running of systems. It is important not to view funding climate change as a separate action but integrate it within environmental and system assessments, being aware that actions need detailed planning and assessment (particularly in areas of water scarcity) since such actions have significant negative tradeoffs and costs[2]. For water and sanitation providers the raised profile of climate change is an opportunity to improve the environmental resilience and the governance of projects which is essential for managing adaptations.

Table 5: Climate change awareness of stakeholders in Antananarivo (Madagascar), Lusaka (Zambia) and Naivasha (Kenya)

Stakeholder	Awareness	Plans/Actions	No. Interviews
Community	Limited	None	30
Local service providers	Limited - Medium	No direct plans	26
Utility	Limited - Medium	No plans - Aware need to adapt system but no direct plans	5
Council	Medium	No direct plans – Council has climate change department	7
Government	Awareness at policy level but little implementation	- Involved in UNFCCC dialogue - Some form of climate change department/networking organisation - REDD - Little regional or district work being completed, seen as issue for central government - Incorporating into policy	19
Researchers	High	Studies being undertaken and advocacy work	3
NGOs	Most have high awareness some limited	- No direct plans - Impact and vulnerability assessments - Set up partnerships/advocacy forums	14
Consultants	Medium	No current projects	2
Local orgs	High	Aware of need to do incorporate the impacts	2

Further Resources

Due to the prominence of climate change there is an abundance of literature. Many of the reports have similar conclusions and they are based on a similar set of references, generally drawing upon the IPCC reports. Predictions of changes to a country's climate are typically based on one or two studies or directly on the IPCC (it is important to trace the original document to determine the resolution of the predictions). Likewise vulnerability assessments are commonly based on limited field data. The following outlines some practical and concise climate change impacts and adaptation resources relevant to this sector:

- CRiSTAL (Community-based Risk Screening Tool – Adaptation and Livelihoods): a tool developed for preparing adaptations to climate change, providing a stepwise methodology for assessing the impacts on livelihoods and identifying adaptations[19]
- DFID WHO Vision 2030 (2010): Evaluates the resilience of water and sanitation technologies to climate change, identifying vulnerabilities and adaptations[1]
- HYOGO: a framework for building the resilience of nations and communities to disasters, includes guiding principles, priorities for action and practical means for increasing reliance; useful to consider alongside work on adaptations[28]
- IRC WASH and Climate Change Group (2010): an ongoing project reviewing the latest research, currently preparing a thematic overview of climate change and WASH and disseminating the latest climate work related to WASH[2]
- ODI Background note: a concise summary of climate change and adaptation[6]
- TEARFUND: a climate change policy overview describing a clear four step process for incorporating climate change into policy at the national level[28]
- Royal Society: A short guide on the science of climate change, highlighting the areas where the science is well established, where there is still some debate and where substantial uncertainties remain[3]
- UNWATER Climate Change Adaptation: an overview of the science of climate change and adaptations at the national level[7]
- USAID: a method for assessing project vulnerabilities to climate change and potential adaptations[16]
- Water Integrity Network: an overview of governance issues that need to be consider when planning adaptations to climate change[29]
- WWF Flowing Forward: The impact of Climate change on freshwater resources[5]

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