Case studies

Adaptation to Climate Change in Water, Sanitation and Hygiene

Assessing risks and appraising options in Africa

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Table of contents

Table of contents

Tables

Abbreviations

CC	Climate change
CIF	Climate Investment Fund
CLTS	Community-led total sanitation
CV	Climate variability
DFID	Department for International Development
DRR	Disaster risk reduction
FCC	Freetown City Council
FUWC	Freetown Urban WASH Consortium
FWMC	Freetown Waste Management Company
GDP	Gross domestic product
GVWC	Guma Valley Water Company (Sierra Leone)
HDI	Human Development Index
INGO	International non-governmental organisation
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme (WHO/UNICEF)
LGA	Local Government Authority (Tanzania)
MDG	Millennium Development Goal
MoHS	Ministry of Health and Sanitation (Sierra Leone)
MoIWD	Ministry of Irrigation and Water Development (Malawi)
MoW	Ministry of Water (Tanzania)
MoWR	Ministry of Water Resources (Sierra Leone)

NAPA	National Adaptation Programme of Action
NGO	Non-governmental organisation
ODI	Overseas Development Institute
SAGCOT	Southern agricultural growth corridor of Tanzania
SALWACO	Sierra Leone Water Company
SSA	sub-Saharan Africa
TMA	Tanzania Meteorological Agency
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Funds
USAID	United States Agency for International Development
WASH	Water, sanitation and hygiene
WHO	World Health Organization
WRM	Water resources management
WSDP	Water Sector Development Programme (WSDP)
WUA	Water user association
WUC	Water user committee

1 Introduction

1.1. Our approach

Over the last decade or so the literature on climate risk assessment and management has proliferated. Dozci (forthcoming) provides a useful overview of climate risk management approaches for WASH, noting the recent shift in focus from the physical aspects of climate change (an impact-led approach) to a more bottom-up focus on vulnerability and uncertainty. In line with current thinking, this report presents an approach that focuses on robust decision-making, identifying low (or no) regrets options for addressing climate risks and other pressures on systems and services.

The risk screening approach described has two main objectives. Firstly, to offer a reasonably simple and straightforward way of assessing risks to delivery of WASH results posed by climate change and other pressures. Secondly, to illustrate how some basic economic principles can be applied to help identify cost-effective adaptation options. The guidance provided (Appendix B, main report) is intended to inform the planning of country-based WASH projects and programmes by DFID staff and their development partners.

For a development partner or non-governmental organisation (NGO) the screening process could form part of a proposal to DFID to demonstrate that due diligence has been followed in assessing risks and options. The approach requires knowledge of the WASH sector and broader country context to complete, but little expertise on climate science. Ideally the assessment would be conducted in a participatory setting, such as an experts' consultation meeting, allowing a consensus to be reached by key sector stakeholders.

The risk assessment addresses the following questions:

- To what extent is the effectiveness of WASH interventions likely to be compromised by climate change as compared to other trends and hazards?
- Does the proposed WASH programme adequately address (either directly or taking account of the work of others) the impacts of variability and change in present and future climate on water resources and WASH services, and the wider impacts of climate change on the target communities?
- Does the proposed WASH programme adequately address (either directly or taking account of the work of others) the enabling environment and institutional capacity to address climate change risks in WASH programming?
- Are the proposed physical infrastructure improvements sufficiently protected against present and future climate risks?

To date the tendency has been to address climate risks in terms of WASH technologies and scheme design – system 'hardware' (Elliot et al., 2011). On the basis that 'software' can be equally if not more important for the sustainability of WASH services, a broader approach is outlined here. The starting point is therefore not the technology itself, but rather an understanding of the range of challenges faced by the sector and the institutional context in which decisions are made.

Accounting for climate risks in DFID country WASH programmes

DFID has developed generic guidance on the Climate and Environment Assessment process (DFID, 2012) which is mandatory for sign off at two stages of business case development – the strategic case and options analysis. However, since guidance is not WASH-specific, country approaches to dealing with risks to WASH vary, as does the priority given to climate change relative to other imperatives. DFID Tanzania, for example, is particularly active on climate change issues having undertaken a portfolio risk screening exercise (refreshed in 2012) and poverty and vulnerability assessments. In Sierra Leone, the most pressing need is to rebuild basic infrastructure and strengthen institutions for service delivery following civil war.

Each of the DFID business cases reviewed for Malawi, Sierra Leone and Tanzania includes a short section on climate and environment impacts (and opportunities) as part of the options appraisal, with differing levels of detail. In Sierra Leone for example, the business case for rural WASH acknowledges that any interventions cannot be separated from the wider need for better natural resource management, whilst the urban programme recognises that increasing climate variability is likely to exacerbate the risk of flooding and the spread of water-borne diseases, even if specific actions to address risks are not spelled out. Clearly the sector faces many problems, and getting basic services 'up and running' reduces vulnerability to a range of threats, including climate change.

Source: stakeholder consultations and DFID business cases

1.2. A two-step process

The new risk screening approach is based on a two-step process, followed by an economic appraisal of adaptation options. The first step is a national-level assessment of key vulnerabilities affecting WASH services that can be set out in a 'traffic light' scorecard, based on documented indicators of vulnerability (or resilience) and more subjective expert judgements. The purpose here is to determine the relative importance of climate change as compared to other risks faced by the WASH sector.

In order to relate this assessment to the risks to DFID (or partner) projects and programmes in a specific country, a second step is needed. Step 2 attempts to determine the extent to which a WASH programme addresses risks posed by climate change to the sector, asking a number of key questions (in the form of a checklist) and providing a scoring system that highlights key areas for closer attention as the programme is designed or modified over time. Step 2 encourages one to consider three main aspects: stakeholders' understanding of climate variability and change, impacts on water resources and implications for the WASH sector; institutional capacity and the enabling environment, for example including WASH policies and guidelines, hydro-meteorological monitoring, research and learning; and finally design and implementation, encompassing catchment protection and impacts of growing demand/water abstraction, in addition to the hardware of water supply and sanitation systems.

The economic assessment (Section 3 of the main report) should then be based on adaptation options arising from Step 2 of the risk screening. Given the uncertainties associated with climate change projections, particularly for rainfall, the economic analysis focusses on 'low or no regrets' activities that will increase the resilience of services under a range of different climate and water futures.

1.3. Testing the methodology

In order to test the draft methodology, three country visits of four to five days each were undertaken over the period July to August 2013, hosted by DFID offices in Malawi, Tanzania and Sierra Leone. Visit objectives were to:

- Obtain feedback on the proposed risk screening approach to inform the methodology and development of guidance materials.
- Identify some of the key challenges facing the WASH sector, including discussion of risks to delivery of DFID WASH results, building a picture of:
  - Existing sustainability challenges with WASH – problems, causes, evidence, impacts - and people's views on the impact of existing climate variability on the functionality and quality of services.
  - Risks posed by future climate change and other pressures on the functionality and quality of services.
  - What is being done (or could be done) to address these risks in terms of adaptation planning.
- Agree a scenario or set of scenarios for the economic appraisal of adaptation options and collect available data to support cost-benefit analyses (CBA).

The main activities undertaken in-country were discussions with DFID staff, a half-day workshop with invited sector stakeholders (national-level experts) and meetings with other key informants. The stakeholders consulted in each country are listed in Appendix B (this report), and include government representatives, NGOs and other donors alongside DFID staff. At the workshops participants suggested a number of possible adaptation actions, not all of which were obviously climate-adaptive measures. Note that in our risk assessment methodology we would expect adaptation options to emerge from Step 2 of the risk assessment and therefore to focus on DFID programme design rather than the sector as a whole. Unfortunately it was not possible to involve stakeholders in the full risk assessment process in the time available. Nonetheless some of the options identified were considered relevant for the economic analysis (see main report).

Comments on the proposed risk screening approach

DFID country WASH programmes and their implementing partners have their own priorities, approaches, capacities and needs. A key challenge was therefore to develop a methodology of relevance to a range of actors in differing national contexts, covering both water supply and sanitation. Noting DFID's existing guidance and processes (DFID, 2013), the task was to develop a sector-specific approach to climate risk screening that could be used by DFID staff and their development partners at various stages of programme design and implementation.

In-country consultations provided a number of useful insights and suggestions which have helped shape final guidance (Appendix B, main report). Participants in the Malawi workshop were particularly interested in the risk screening approach and the translation of abstract resilience concepts into WASH sector realities. In Sierra Leone, a clear message was the need to focus on the existing 'adaptation deficit' – the inability to deal with existing climate variability and other pressures. Hence the importance attached to Step 1 of the of the assessment process that places climate change alongside other risks.

In terms of the economic analysis, most stakeholders could not envisage carrying this out themselves but they could see the value of having the results and understanding the data and assumptions underpinning the analysis. DFID Tanzania is particularly keen to better understand the economics of adaptation options, including examples and guidance on valuing benefits and conducting CBA. It was pointed out that

interventions are sometimes necessary even if uneconomic in conventional terms, or if risks are high making benefit (and cost) streams uncertain. Internal cross-subsidies within programmes can help address such cases.

Source: stakeholder consultations

1.4. Report overview

In this Case Study Report we present the findings for Malawi, Sierra Leone and Tanzania in turn, firstly providing an overview of the country WASH context, climate trends and projections, and the DFID programme(s), and secondly discussing issues raised by national experts in relation to the climate change risk assessment. Note that both the DFID programmes in Malawi and Tanzania are rural in focus, whereas Sierra Leone also has an urban component.

A number of qualifications should be highlighted. First, the country case studies should not be viewed as comprehensive risk screening exercises or pilot studies. Rather, they provided the means to develop and seek a range of views on the methodology proposed. For this reason we do not present 'results', but rather provide insights from country visits on key national-level issues for WASH and potential implications for DFID programmes. Second, the traffic light scores emerging from the risk assessment illustrate what a completed assessment might look like, with the proviso that these are tentative and subject to detailed review by relevant national experts. Further detailed discussions with national experts would be required to verify findings and develop solid adaptation plans.

2 Malawi case study

2.1. Country WASH context

Malawi remains a very poor country[1] with a large and rapidly growing population (over 15 million in 2011) and relatively high population density (139/km^2) (UN Data, 2013). The economy is predominately agricultural and currently more than 80% of the population still resides in rural areas, although urbanisation is an ongoing trend (*ibid.*) The majority of people are subsistence farmers who are highly vulnerable to a range of hazards including unreliable seasonal rainfall, floods or droughts, and illnesses (for example due to poor sanitation), which undermine agricultural productivity and household food security (MoMNRE, 2006).

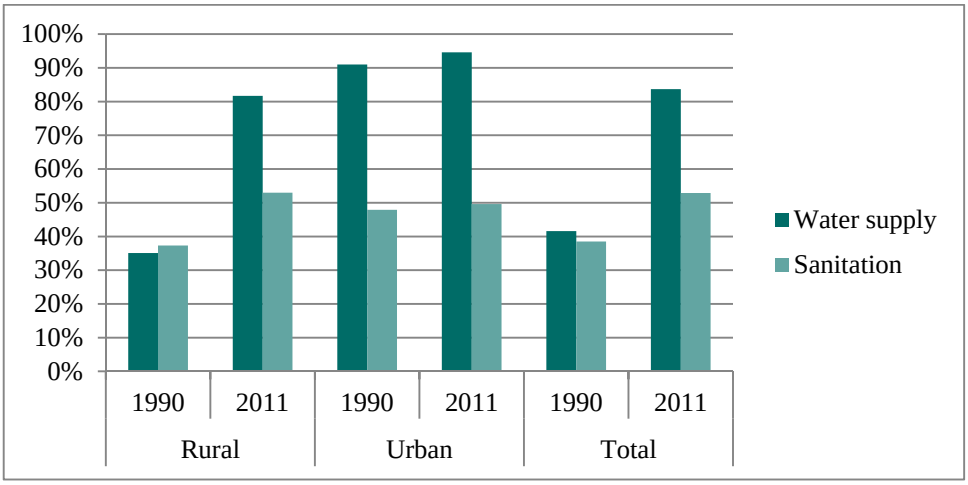
Malawi has made impressive progress on **water supply coverage** since 1990 (Figure 1) and is currently on track to meet the water MDG target on water supply by 2015. Both rural and urban coverage figures appear high (at 82% and 95% respectively in 2011; WHO/UNICEF, 2013). Nonetheless, there are serious present and future threats to the sustainability of water supply services. Nationally about 16% of Malawians (2.56 million people) still do not have access to improved water supply (*ibid.*). In rural areas water supply is characterized by inequitable coverage and non-functionality of water points, the latter currently estimated at 30% (MoIWD, 2012; see also Baumann & Danert, 2008). Access to improved water appears to be better in urban areas yet in reality water supplies are often intermittent and unreliable due to low efficiencies in operations and high levels non-revenue water.

On a more positive note, the government has made strides on the enactment of the National Water Resources Act 2013, which was approved by Cabinet, Parliament and gazetted within the last year. This long awaited act will support more effective management of the country's critical water resources, support improved monitoring, licensing, and strategic planning and development at river basin level, as well as improved flood forecasting and flood risk management.

Expansion of **improved sanitation coverage** poses similar challenges in Malawi as elsewhere in sub-Saharan Africa, lagging behind water supply. The percentage of the population using improved sanitation is estimated at 53% nationally (53% rural and 50% urban; Figure 1) whilst slightly over one third of the population use shared facilities (rural 31% and urban 45%; WHO/UNICEF, 2013). Around 6% of the population still practices open defecation (*ibid.*) and hygiene standards are relatively low. WASH-related diseases are prevalent; for example in 2008 there were estimated 6,169 under five deaths due to diarrhoea (Black et al., 2010) and cholera outbreaks occur almost every year (WHO, 2010). Management of urban on-site sanitation and peri-urban faecal sludge management have been identified as key issues in country consultations. Affordability of robust improved latrines coupled with technical difficulties (e.g. ground conditions) in some areas also makes it difficult to ensure sustainability and to convince households to invest.

[1] Malawi has an HDI ranking of 170 (below the SSA average; UNDP 2013) and a GDP per capita of 268 USD (World Bank 2013, data for 2012).

Figure 1: WASH coverage in Malawi



Source: JMP estimates (WHO/UNICEF, 2013)

Equity of access to WASH services is clearly a problem, evident in the disparities between urban and rural areas, or between urban and peri-urban settlements. NGO mapping shows coverage far lower than average in some areas - as low as 22% access to safe water, 5% improved sanitation (DFID Malawi, n.d.). The majority of funding goes to urban water supply; rural areas and the sanitation and hygiene subsector are noticeably underfunded. Gender imbalances persist as women tend to carry the burden of fetching water, often walking long distances and carrying heavy loads, with attendant risks to personal security and health, as well as reduced time for other productive activities (DFID Malawi, n.d.). In light of these inequities DFID Malawi is supporting rural WASH development with an emphasis on improved access for women (see box below).

Other challenges include degradation of water resources, inadequate financing, insufficient institutional capacity and inadequate mitigation measures for water-related disasters (DFID Malawi, n.d.). Increased levels of local participation are recognised as a crucial factor to improve infrastructure functionality and access to improved services. Historically sectoral leadership and coordination between sector agencies has been weak and government capacity particularly lacking at local level (AMCOW et al., 2006). More recently, however, there have been demonstrated improvements in sector coordination among various players at different levels. At the national level, several forums have been utilized to strengthen coordination of the sector such as annual Joint Sector Review, quarterly Sector Working Group meetings as well as Technical Working Groups. Similar efforts have been carried out by NGOs through the establishment of the WES Network. Similarly at the district level, the District Coordination Teams support the effective coordination of the sector (DFID Malawi, personal communication).

DFID Malawi's WASH programme

DFID is providing up to £20m over a three year period (2012-15) to support the delivery of rural water, sanitation and hygiene services in Malawi. The project is managed by UNICEF and implemented by NGOs World Vision International, GOAL, Development Aid from People to People (DAPP) and Concern Universal, with WaterAid providing policy and governance support. Expected results include 850,000 people (including 442,500 women) gaining access to improved water and sanitation facilities and one million people (510,000 women) adopting key hygiene practices.

The programme goes beyond the provision of new infrastructure to include backstopping support systems for Water User Committees, establishment of spare part supply chains, rehabilitation of existing water points (broken boreholes and community managed piped water schemes) and the strengthening of WASH institutions.

The programme focuses on ten of the 'least served' districts in Malawi identified through waterpoint mapping[2]. Due to the existing imbalance in funding allocations between rural and urban WASH, DFID has chosen to focus on rural areas, targeting the poorest communities and schools. The approach focuses on community or household management for water points and sanitation facilities, respectively (with the exception of schools or clinics), coupled with hygiene promotion and an emphasis throughout on equity, and particularly gender-based equity.

Source: summarised from DFID Malawi (n.d.)

2.2. Climate trends and projections

Malawi, a landlocked country in southern Africa, has a tropical climate but due its high elevation temperatures are relatively cool, ranging from 18-19°C in the winter (June to August) to 22-27°C in the warmest months (September to January) (McSweeney et al. 2010a). Mean annual rainfall shows significant spatial variation, ranging from 700mm to 2,400mm, with a national average of 1,180mm (data for 2006; FAO, 2013). The rainy season falls from November to February, or into March-April in the north of the country (McSweeney et al. 2010a). Although Malawi is not currently considered water scarce in physical terms - per capita renewable freshwater resources are estimated at 1,088m^3 per annum (data for 2011; FAO, 2013) - it experiences high inter-annual variability in the timing and intensity of rainfall with a high likelihood of dry spells (MoMNRE, 2006).

Inter-annual variability aside, there are no clear trends in rainfall patterns to date although temperatures have been on the increase since 1990 at an average rate of 0.21°C per decade. Moreover, projections do not indicate any substantial changes in future average annual rainfall. Nevertheless there are likely to be larger seasonal differences over time with projections tending towards increased rainfall in the wet season and decreased rainfall in the dry season, and an increase in heavy rainfall events – exacerbating the risk of floods and droughts. Temperatures will also continue to rise by up to 3°C by the 2060s[3], leading to increased potential evapo-transpiration (McSweeney et al. 2010a). Appendix A provides a summary of climate trends and projections for the three case study countries. The main impacts of climate change in Malawi are likely to be on rainfed agriculture, followed by water resources and supply (MoMNRE, 2006).

[2] The least served Districts identified are: Karonga and Rumphi in the Northern Region; Kasungu, Dowa, Mchinji and Lilongwe in the Central Region; and Nsanje, Chikhwawa, Phalombe and Balaka in the Southern Region. In particular, areas of Karonga affected by the 2009 earthquake are targeted.

[3] High emissions scenario

2.3. Preliminary findings of the risk assessment

Although there is a high awareness of climate change in Malawi and climate-related activities linked to food security[4], climate change does not appear to be the highest priority concern in the WASH sector. **Step 1** of the risk assessment supported the argument that numerous other factors may be more important to Malawi's development trajectory than climate change alone, the main exception being the (rainfed) agriculture sector. The major stresses and threats to WASH services appear to arise from: rapid population growth; increasing demands for water; rising production of faecal and solid waste; and the degradation of the natural environment, with knock-on effects on hydrology and water quality (see MoMNRE, 2006; Carter & Parker, 2009). In the latter case, there is evidence that runoff is becoming more flashy and that sediment loads are increasing. These trends may be exacerbated by increasing rainfall intensities, but the underlying causes are primarily population-related.

[4] A number of the organisations that took part in the workshop are working on climate change adaptation, particularly in relation to food security.

Table 1: Sector level risk assessment for Malawi

NB. Scores are presented for a number of quantitative and qualitative indicators. The former are based on publically available data sets (refer to the guidance in Appendix B, main report). Note that the latter are based primarily on key documents and in-country discussions but have not been subjected to detailed analysis by key stakeholders and so should be considered provisional.

		Score					
No	**Factor**	**1**	**2**	**3**	**4**	**5**	**Comments**
1.1	Government effectiveness						Malawi ranks in the 25-50 percentile according to this indicator.
1.2	WASH and other policies						The WASH sector has appropriate policies, although climate change is not prominent.
1.3	WASH institutional capacity						Competence at central government level but local capacity generally low & districts grossly under-funded.
1.4	Cross-sector & trans-boundary cooperation						Cross-sector coordination generally limited & and trans-boundary disagreements exist (with Tanzania).
2.1	GNI per capita						As a least developed country Malawi scores 1 on this indicator.
2.2	WASH and national budget						WASH represents 2% of the national budget according to DFID's business case.
2.3	Adequacy of WASH recurrent budget						District governments have very small budgets for new works let alone supporting existing systems. User tariffs unrealistically low.
3.1	Technology						Mostly boreholes - should be relatively resilient but often not sited and drilled properly. Hand-dug wells and gravity-fed schemes less resilient. On-site sanitation prone to flooding in some areas.
3.2	Design & construction standards						Some standards exist, but they do not take account of climate change.
3.3	Standards observed - implementation						There is not rigorous and widespread application of high standards of design and construction.
4.1	Monitoring agencies						The responsible government agencies are desperately under-funded.
4.2	Monitoring networks						Meteorological & hydrological (including groundwater) networks exist, but maintenance is a challenge.
4.3	Environmental data						The availability of data from the existing networks is problematic. No regular publishing takes place.
5.1	National population growth						Population is projected to grow by a factor of 2.74 between 2010 and 2050.
5.2	Urban population growth						Urban population is projected to grow by a factor of 6.77 between 2010 and 2050.
5.3	Deforestation and env. damage						Deforestation estimated at 2.8% pa (AFIDEP & PAI 2012). Fuel wood & timber for construction becoming scarce. Hydrological impacts widely experienced i.e. increased flooding.
6.1	Mean rainfall change						No significant change to 2010.
6.2	Change in annual 5-day max rainfall						A small rise in this indicator is projected.
6.3	Climate change impacts in general						Impacts of droughts & dry spells on agricultural livelihoods could be serious. More intense rain may contribute to siltation of reservoirs.
7.1	Human development index						Malawi ranks 170 out of 186.
7.2	CSOs/media accountability						Malawi's World Bank score for voice and accountability places it in the 25-50 percentile by rank.

Table 2: Programme-level risk assessment – DFID support to rural WASH in Malawi

NB. The contents of this table are provisional and subject to consensus from the relevant experts. We would emphasise that the indicators are a measure of programme risk rather than programme quality. Many of these factors are strongly influenced by what is going on in the rest of the sector, and not within the control of programme stakeholders. It is quite conceivable that an excellent programme could receive a sea of red scores simply because it is taking place in the context of large risks, or because it is may be very difficult or beyond the scope of the programme to address those areas under current circumstances. Nevertheless, the programme should arguably be doing all that is possible to address the most important risks.

				Score
Aspect	**Element**	**Question**	**Response and proposed actions**	
Understanding of climate impacts	Present climate	Is there good understanding among all stakeholders of existing climate variability, its impacts on water resources and its implications for WASH services?	Few (if any) WASH organisations involved in the programme make use of existing hydro-met data; little is known about the actual contribution of CC to problems of water source failures; it is not clear whether apparently increasing flood impacts reflect climate changes, land management practices or increasing migration to flood-plains. Further studies are needed to disentangle these issues.	
	Future climate	Is there good understanding among all stakeholders of projected climate change, its likely impacts on water resources and its implications for WASH services?	High awareness of the general risks posed by CC, and keen interest in the subject, but project stakeholders do not have a detailed understanding of CC projections or how future climate may impact on WASH services. More applied research is needed.	
Developing capacity, enhancing the enabling environment	WASH policies	Does the programme design contribute to the development and promotion of strong sector policies which recognize the multiple pressures on WASH services, including that posed by climate variability and change?	The National Water Policy (2005) recognises CV & CC as threats, but the extent to which it addresses these issues – apart from setting policy objectives for disaster management – is limited. The National Sanitation Policy (2008) does not mention CV or CC. There is a relatively new National CC Policy (2012) but this does not address specific sectors, so WASH is not highlighted. Sector programmes which acknowledge the importance of CV/CC should advocate for explicit inclusion in policy documents.	
	Technical guidelines and standards	Does the programme design contribute to the development and promotion of WASH guidelines and standards which take adequate account of climate change?	Technical guidelines relating to borehole depth, catchment protection (gravity-flow schemes) & flood protection (sanitation) may exist, but are probably not widely disseminated. Construction supervision is often non-existent or very limited. More could be done to develop, disseminate & enforce standards by all stakeholders.	

	Monitoring	Does the programme design contribute to strong and effective systems for monitoring of water resources and WASH services?	Hydro-meteorological monitoring institutions are in place, and networks of rain gauges, river flow stage boards and groundwater monitoring points exist. However, the Water Resources Department of MoIWD is grossly under-funded and monitoring data is not published or easily available. Large sub-national programmes such as this should include an element of support to national monitoring efforts, even if only through advocacy for more appropriate budget allocations.	
	Research and learning	Does the research / learning component of the programme include areas related to CC?	The Ministry of Environment & CC has responsibility for this aspect nationally, but the WASH sector itself should undertake relevant studies and investigations. There does not appear to be much literature relating CC to WASH in Malawi. The programme could make a useful contribution here for a limited % of total budget.	
	Capacity development	Does the programme include a significant component of general and CC-specific capacity development, addressing the needs of WASH service users, local Government, private sector, NGOs, central Government and development partners?	The programme will be strong on capacity development of households, communities and water user committees. It also contains an element of capacity building for staff at district level and for the private sector. There is some training on environmental degradation but no explicit capacity building component on climate awareness.	
	Flexibility and responsiveness	Does the programme contribute to the strengthening of flexible national and local planning, budgeting and emergency response capabilities which can effectively respond to gradual and rapid onset change?	The inadequacy of environmental monitoring makes responsiveness to slow-onset drought-related impacts difficult. Emergency response to rapid-onset flood events does take place, but linkages between adaptive responses & disaster preparedness and response are not well developed. More work needs to be done to identify adaptive actions (especially in relation to floods) which could obviate some of the need for emergency response.	
Design and implementation	Overall design philosophy	In general how does the design of physical infrastructure in the programme take account of climate variability and change?	There is little evidence that design approaches in the programme are modified to account for increasing climate risks. Consideration should be given to specific low-regrets design modifications which take account of possible increased drought and flood frequency.	
	Catchment and source protection	Does the programme include adequate measures for source and catchment protection?	This is recognised as a key issue in gravity-flow system design and rehabilitation, and also recognised in relation to point sources, although implementing organisations may be less clear on what specific actions regarding source protection zones are appropriate. More work is needed in this area.	

	Impact of major abstractors on local water availability	Does the programme take due account of the indirect impacts of climate change and other socio-economic and demographic trends on WASH, especially those felt through (increasing) agricultural, industrial and urban water abstractions?	There is no explicit reference to this in programme documentation and it is generally assumed that rural groundwater resources supplying gravity-fed schemes are unaffected by such abstractions. The expansion of rainfed agriculture in catchments supplying gravity schemes represents a threat to water quality and seasonality of flows.		
	Water supply system design and construction	How does the design and construction of water source works take account of present and future variability of water levels and / or flows? Does the sizing of service reservoirs and larger water storage structures take due account of projected changes in the timing and magnitude of available flows? How is the design of piped distribution systems informed by climate considerations? How does the design of water treatment systems allow for future possible changes in water quality and quantity caused or contributed by climate change? Does the selection of water lifting technology allow for future increases in fossil fuel energy costs? Is there a preference for renewable energy sources?	It is not clear that these issues are explicitly considered in the programme. The programme is mainly using boreholes, which is generally considered a relatively resilient technology, but current quality of construction is low e.g. boreholes are not being drilled properly. There is also some anecdotal evidence of boreholes drying up due to seasonality (implying lack of consideration of CV in design – the risk of dry boreholes could increase with CC).		
	Sanitation system design	Does the programme design include modifications to latrines and other on-site sanitation technologies to reduce their vulnerability to floods? In any urban sanitation components of the programme, is due attention being paid to storm water drainage and solid waste management? How does this address the possibility of higher flood flows in future? How does the design of sewage conveyance and wastewater treatment allow for future climate changes which affect quality and quantity of discharges?	This is not certain. In-country stakeholder discussions mainly focused on water. There are lots of flood prone areas in Southern Malawi, although these aspects are not *explicitly* addressed in the programme (the DFID business case does not mention CV or CC in relation to technology choice or design) but may be addressed implicitly.		

Step 2 of the assessment highlighted a number of possible gaps in addressing climate-related risks in the WASH sector, both nationally and at programme level. These are tentative findings; further verification by national experts would be required to draw firm conclusions.

Understanding of climate impacts

There is a consistent and widespread perception that drought and dry-spell durations have increased over recent decades, as have the magnitude and frequency of floods (although not confirmed by the scientific data). Both would have implications for sustainability of WASH services, although current understanding of climate risks in Malawi remains limited. Stakeholders in the WASH sector appear to have a high awareness of (and interest in) the general risks but few organisations are currently making use of hydro-meteorological data to inform project design and implementation. At the same time, there are considerable gaps in the scientific data that make it difficult to determine how future climate change may impact on programme results. For example, the contribution of climate variability or change to problems such as water source failure is largely unknown. It is similarly unclear whether perceived increases in flood risk reflect climate changes, land management practices or increasing migration to flood-plains.

Developing capacity and enhancing the enabling environment

There are a number of **policies** in place of relevance to WASH. The National Water Policy (MoIWD, 2005) recognises climate variability and change as threats, but the extent to which it addresses these issues – apart from setting policy objectives for disaster management – is limited. The National Sanitation Policy (MoIWD, 2008) does not mention climate or climate change at all. There is a relatively new National Climate Change Policy (2012) but this does not address specific sectors, so WASH is not highlighted. However, Malawi's NAPA (MoMNRE, 2006) does draw attention to the threats posed by dry spells, droughts, intense rainfall, riverine floods and flash floods and their impacts on food and water security, water quality, energy and livelihoods. The links between drought/flood prevalence and water borne diseases are also noted. Sector programmes which acknowledge the importance of climate variability and change could potentially advocate for explicit inclusion of climate statements in the relevant policy documents if not doing so already.

Technical guidelines relating to borehole depth, catchment protection for gravity flow systems and flood protection for sanitation may exist but may not be widely known or used (this needs to be verified). In general, construction supervision is non-existent or very limited. This is a nation-wide problem; more could be done by all sector actors to develop, disseminate and help monitor and enforce technical standards.

Hydro-meteorological monitoring institutions are in place and networks of rain gauges, river flow stage boards and groundwater monitoring points exist. However, significant challenges remain in terms of human and financial capacity. The Water Resources Department of the Ministry of Water Development and Irrigation (MoIWD) is under-funded and monitoring data are not published or easy to access. Large non-governmental programmes (such as the DFID programme) should arguably include an element of support for national monitoring, even if only through advocacy for more appropriate budget allocations.

The inadequacy of environmental monitoring makes responsiveness to slow-onset drought-related impacts difficult. **Emergency response** to rapid-onset flood events does take place, but the links between adaptive responses and disaster preparedness and response are not well developed. In general, more work could be done to identify potential adaptation actions (especially in relation to floods) which would then reduce the need for emergency response.

The Ministry of Environment and Climate Change has a responsibility for national **research and learning** on climate change, but the WASH sector should also undertake relevant

studies and investigations. As noted above, there does not appear to be much information available relating climate change to WASH in Malawi (although we have not undertaken a full review of the literature). Large programmes could potentially make a useful contribution here for a limited percentage of the total budget.

The DFID programme (as per the business case) is strong on **capacity development** of households, communities and Water User Committees (WUCs). The programme also contains an element of capacity building for staff at district level and for the private sector. For example, selected mechanics and shop owners in the area are given training to provide support to communities on operation and maintenance. Although there is no explicit component of climate awareness in planned capacity development activities, the training for staff, WUCs and communities does cover issues of environmental degradation and conservation measures that need to be put in place.

Design and implementation

There appears to be little evidence that **design approaches** for WASH take adequate account of climate risks. In particular consideration should be given to low-regrets design modifications which could increase resilience to increased drought and flood frequency – without attempting to fully 'climate-proof' assets.

Finally, **catchment and source protection** are recognised as key issues in gravity flow system design and rehabilitation. It is also recognised in relation to point sources, although implementing organisations may be less clear on what specific actions regarding source protection zones are appropriate. More work is needed to determine appropriate catchment and source protection measures in different contexts.

Adaptation options

At the workshop the participants suggested a number of possible adaptation actions for the Malawi WASH sector, not all of which are obviously climate-adaptive measures. This is a long-list rather than a consensus on priorities and some options are more widely relevant (e.g. relating to the enabling environment) whereas others are likely to be context-specific (e.g. focussing on technology options). Note that in our risk assessment methodology we would expect adaptation options to emerge from Step 2 of the risk assessment and therefore to focus on DFID programme design rather than the sector as a whole. Unfortunately it was not possible to involve stakeholders in the full risk assessment process in the time available; nonetheless some of the options identified here (in bold) are relevant for the economic analysis.

Water resources management

- **Catchment protection/management** to a) protect gravity flow systems catchments; and b) encourage groundwater recharge to point sources
- **Strengthen hydro-meteorological monitoring data quality and availability**

Water supply

- Undertake a transition from hand-dug well construction to manual drilling
- Adopt an alternative deep-well hand pump in addition to the Afridev (and drill deeper)
- Transition from individual water point committees to multiple-point water source management
- Protect gravity flow systems and pumped water intakes / adapt to lower water levels
- Transition from pumped groundwater to spring protection

- **Undertake a study to determine the contribution of hydrological trends on water source failure**

Sanitation

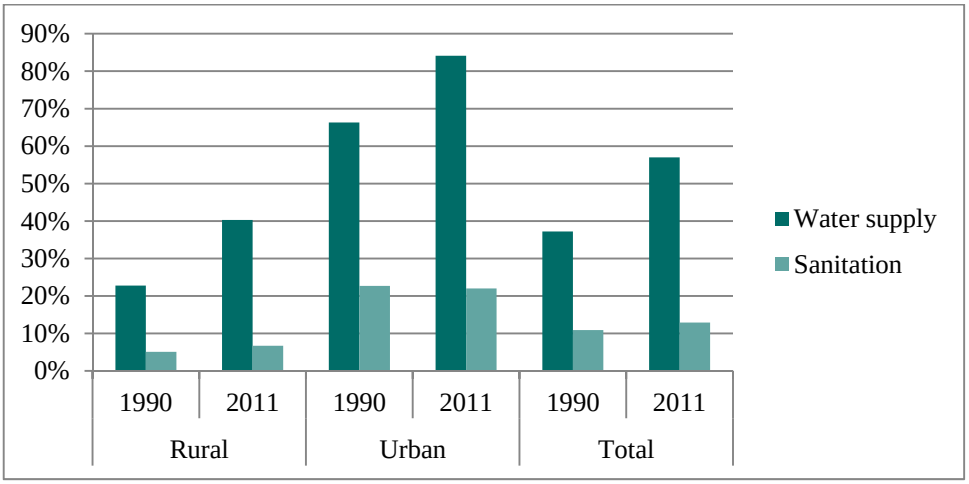
- **Construct flood-resistant latrines by a combination of pit lining and raised plinths**
- Develop alternative materials and designs for latrines to deal with timber shortages and migration

3 Sierra Leone case study

3.1. Country context

Sierra Leone is a country recovering from a decade-long civil war during which much of its WASH infrastructure was put out of service. Since the signing of the peace agreement in 2002 the country has made steady progress in the transition from a state of emergency to recovery and ongoing reform processes (including new laws, policies and institutions) have created an enabling framework for WASH development (AMCOW et al., 2010a). Nevertheless huge challenges remain in all sectors. From the 1980s onwards GNI dropped from USD390 to as low as USD140 in 1993 and has only recently recovered (surpassing 1980s levels in 2008; World Bank, 2013). Around 77% of the population still lives in poverty[5] and Sierra Leone ranks below average among sub-Saharan countries on the Human Development Index[6] (UNDP, 2013).

Figure 2: WASH coverage in Sierra Leone



Source: JMP estimates (WHO/UNICEF, 2013)

Current estimates provided by the JMP for Sierra Leone put **improved water supply** access at 57%, with **sanitation** lagging behind at 13% (WHO/UNICEF, 2013; see Figure 2). There are large inequities between rural and urban areas, although many sector actors have questioned whether the high figure for urban water supply factors in quality of drinking water sources (e.g. hand-dug wells). Moreover, national averages obscure the disparities between regions - Western Areas (including Freetown) have the highest access to improved water supply at 87% whilst Northern regions have the lowest at 30% (DFID Sierra Leone, 2012). There are also notable differences between households, with wealthier or more educated households being more likely to use improved drinking water and have improved

[5] Population below income poverty line of PPP USD1.25 per day

[6] HDI 0.359 (2012) ranking 177 out of 187 countries

sanitation (DFID Sierra Leone, 2012; citing others[7]). The impact of poor access to WASH particularly affects women and girls.

In Sierra Leone the responsibility for the development of **rural** water supplies has been devolved to local government, with an emphasis on community operation and maintenance and, at least in the DFID programme (see box below), the spare parts are provided through private sector supply chains. Yet capacity is severely lacking on all fronts. The government's National Water Supply and Sanitation Policy (2011), which DFID's partners are implementing, adopts a Community-Led Total Sanitation (CLTS) approach– centred on self-supply, the promotion of affordable technologies and awareness raising activities.

In **urban** areas the situation is somewhat different as WASH services should (in theory) be delivered through utilities such as the state-owned Sierra Leone Water Company (SALWACO), Guma Valley Water Company (GVWC) and Freetown Waste Management Company (FWMC). However, in Freetown the deterioration of GVWC, illegal connections and environmental degradation mean that water quantity is diminishing and it is the poorest households that are most affected. Similarly, waste management systems have broken down and there is an urgent need to deal with the solid waste accumulating in streets and drains, and to ensure the proper disposal of faecal sludge. Low lying slums are particularly vulnerable to flooding due to poor drainage systems, with contaminated water contributing to the spread of water borne disease including cholera (DFID Sierra Leone, 2013).

If Sierra Leone is to meet its MDG targets for 2015[8], an estimated USD164 million and USD40 million of investments will be required annually for the new and rehabilitated water and sanitation facilities respectively (AMCOW et al. 2010a). Current investments fall well short of these targets, with meagre government allocations hampering the reform process. The high risk of corruption and mismanagement of funds also makes it is difficult for donors to channel money through government institutions in the form of budget support. Finally, it is expected that operation and maintenance costs will be recovered by users but in reality cost recovery has not been addressed and limited attention to 'software' continues to undermine sustainability of WASH services.

DFID Sierra Leone's WASH portfolio

DFID is implementing a major £50 million programme over the period 2010 to 2016 with the Ministry of Water Resources (MoWR) and the Ministry of Health and Sanitation (MoHS). The programme has three complimentary elements:

- Technical support to the MoWR and MoHS to implement the National Water and Sanitation Policy of 2011, which includes:
  - Legislation to create a National Water Resources Agency and an independent water and energy regulatory commission.
  - Legislation to strengthen the Guma Valley Water Company and the Sierra Leone Water Company.
  - Restructuring and establishment of reform management structures within the Ministry including strengthened relations between MoWR and the MoHS and waste management.
  - Capacity building in seven districts to support planning and management of water including community based approaches for water resource management and water security.

[7] Freetown INGO Urban WASH Consortium KAP survey

[8] National MDG targets are 74% and 66% for water supply and sanitation respectively

- WASH service delivery improvements in Freetown focussing on slum/poor areas through support to an NGO Consortium, led by Oxfam, to work at community level in cooperation with GVWC and Freetown City Council.
- CLTS programmes in six districts together with improved WASH facilities in rural schools and clinics implemented through PLAN International and UNICEF.

The DFID programme sits alongside other donor programmes, the principal projects being:

- African Development Bank (AfDB) support for urban water and sewerage services in three main towns in Sierra Leone (Bo, Makeni and Kenema).
- Support from the AfDB for rural WASH in regions not covered by the DFID rural WASH projects (DFID is co-funding this programme which includes a GEF co-funded component addressing climate change).
- Planned support from the Netherlands Government for rural WASH in regions not covered by the DFID or AfDB funded rural WASH projects.
- JICA support for urban water supply improvements in small towns in Sierra Leone.

The most climate-relevant aspect of DFID Sierra Leone's current portfolio is the technical support to the Ministry of Water Resources[9]. A large component of this project is focused on improving the way in which water resources are managed and includes establishing water resources management (WRM) institutions, and addressing associated environmental monitoring activities.

Source: DFID Sierra Leone (2012, 2013) supplemented by in-country consultations

3.2. Climate trends and projections

Sierra Leone is located in western Africa on the Atlantic Coast, having a tropical climate highly influenced by the West African Monsoon. Temperatures are relatively constant throughout the year, ranging from 22-25˚C in the wettest season to around 25-27˚C the rest of the year. Rainfall is highly seasonal and tends to fall in a very short period of time (during the wet season) with high intensity rainfall events that can lead to flooding (McSweeney et al., 2010b). Freetown gets around 1000mm of rain a month during the peak of the rainy season (July-September); for comparison London gets about 600mm a year. Conversely, during the dry season the monthly rainfall average is close to zero for several months.

Evidence suggests that annual temperatures have risen by 0.8˚C since 1960 (an average of 0.18˚C per decade) and mean annual rainfall has decreased but it is unclear whether the latter is a long-term trend or merely natural variability. The hydro-meteorological data available are insufficient to determine trends in temperature or rainfall extremes, whether positive or negative (McSweeney et al., 2010b).

Future projections indicate temperatures rises of up to 2.6˚C by the 2060s and up to 4.6˚C by the 1990s (high emissions scenario) and substantial increase in the number of 'hot' days and nights. Meanwhile, there is strong disagreement among climate models on rainfall projections across western Africa, with different models predicting increases or decreases for Sierra Leone (the tendency being towards an overall increase in average annual rainfall) (McSweeney et al., 2010b). What is more certain is that, like Malawi (and Tanzania) there will be an increase in the number of extreme rainfall events, particularly in the wet season

[9] Through Adam Smith International

(*ibid.*), which implies a heightened risk of flooding events. Sierra Leone is also vulnerable to sea level rise which is likely to exacerbate erosion and the risk of flooding in lowland coastal areas (UNDP, 2012).

3.3. Preliminary findings of the risk assessment

An argument made by several stakeholders in Sierra Leone was that more effort needs to be put into coping with the existing variability alongside non-climatic risks, rather than worrying about marginal changes in future (and highly uncertain) climate. A key finding of the government's water point mapping review (MoEWR, 2012) is that many water points are seasonal, with up to 40% of protected in-use water points providing insufficient water during the dry season. Results from **Step 1** of the risk screening support the view that the relative magnitude of climate change as compared to other risks is particularly low for Sierra Leone. For example, there is generally little recurrent finance in the WASH sector, communities are extremely poor and WASH institutions weak at all levels.

Environmental degradation is considered a significant and widespread problem (DFID Sierra Leone, personal communication). For example deforestation around Freetown is a major concern, and mining and agro-industry are increasing rapidly with little regulation, the latter potentially leading to increased extraction of water resources and pollution. Meanwhile, population is projected to grow by a factor of 1.79 between 2010 and 2050 (UN Data, 2013); less rapid than Malawi or Tanzania, but increasing pressure on existing services and resources.

Table 3: Sector level risk assessment for Sierra Leone

NB. Scores are presented for a number of quantitative and qualitative indicators. The former are based on publically available data sets (refer to the guidance in Appendix B, main report). Note that the latter are based primarily on key documents and in-country discussions but have not been subjected to detailed analysis by key stakeholders and so should be considered provisional.

		Score					
No	**Factor**	**1**	**2**	**3**	**4**	**5**	**Comments**
1.1	Government effectiveness						Sierra Leone ranks in the 0 – 20 percentile according to this indicator.
1.2	WASH and other policies						Water & sanitation policy has little climate focus. The environmental sanitation policy is still under review.
1.3	WASH institutional capacity						Very low capacity at all levels of government.
1.4	Cross-sector & trans-boundary cooperation						Cross-sector coordination is limited, despite an MOU signed in 2012. Few trans-boundary issues.
2.1	GNI per capita						Sierra Leone is a LDC
2.2	WASH and national budget						WASH was about 3% of the GoSL budget in 2011, according to WASHwatch.
2.3	Adequacy of WASH recurrent budget						There is generally little recurrent finance in the sector. Communities are extremely poor.
3.1	Technology						Vision 2030 (Howard & Bartram, 2009) suggests hand-dug wells are a vulnerable technology; these are very prevalent in Sierra Leone.
3.2	Design & construction standards						Some standards in development (e.g. for hand-dug wells) but for few technical areas; not yet widely used.
3.3	Standards observed - implementation						The prevalent view is that construction standards are fairly poor.
4.1	Monitoring agencies						Agencies hydro-met monitoring are extremely weak.
4.2	Monitoring networks						Almost none exist. There are the beginnings of some plans, but nothing will be seen for a while.
4.3	Environmental data						Almost zero data.
5.1	National population growth						Population is projected to grow by a factor of 1.79 between 2010 and 2050.
5.2	Urban population growth						Urban population is projected to grow by a factor of 2.89 between 2010 and 2050.
5.3	Deforestation and env. damage						A significant problem, including high deforestation around Freetown. Mining & agro-industry are increasing rapidly with little regulation.
6.1	Mean rainfall change						No change predicted by 2030 for 2 out of 3 climate scenarios.
6.2	Change in annual 5-day max rainfall						No data for 2030s, but for 2060s the rating would be 5-9mm increase, suggesting a possible 2-5mm increase by the 2030s, which is very small.
6.3	Climate change impacts in general						Impacts could be serious but models disagree on rainfall predictions for West Africa in general. Extreme poverty means that Sierra Leone is vulnerable to almost any potential changes.
7.1	Human development index						Sierra Leone ranks 177 out of 186.
7.2	CSOs/media accountability						Sierra Leone's score for voice and accountability places it in the 21-40 percentile by rank.

Table 4: Programme-level risk assessment – DFID support for the Freetown Urban WASH Consortium

NB. The contents of this table are provisional and subject to consensus from the relevant experts. We would emphasise that the indicators are a measure of programme risk rather than programme quality. Many of these factors are strongly influenced by what is going on in the rest of the sector, and not within the control of programme stakeholders. It is quite conceivable that an excellent programme could receive a sea of red scores simply because it is taking place in the context of large risks, or because it is may be very difficult or beyond the scope of the programme to address those areas under current circumstances. Nevertheless, the programme should arguably be doing all that is possible to address the most important risks.

				Score		
Aspect	**Element**	**Question**	**Response and proposed actions**			
Understanding of climate impacts	Present climate	Is there good understanding among all stakeholders of existing climate variability, its impacts on water resources and its implications for WASH services?	Difficult due to lack of hydro-met data available; programme designs do account for existing variability in the sense that they plan for regular flooding in Freetown's informal settlements, based on local information (although information is not collected routinely & is not always reliable); efforts are needed to collect information consistently and to rehabilitate / develop hydro-meteorological monitoring networks.			
	Future climate	Is there good understanding among all stakeholders of projected climate change, its likely impacts on water resources and its implications for WASH services?	CC is less of a discussion point in the urban WASH sector (the focus is on current issues) and population growth and density are perceived as much more pressing issues than CC. Although there was fairly limited knowledge among stakeholders of existing climate predictions for Sierra Leone, this is not considered to be a significant limitation to planning, particularly given the high levels of uncertainty in the science.			
Developing capacity, enhancing the enabling environment	WASH policies	Does the programme design contribute to the development and promotion of strong sector policies which recognize the multiple pressures on WASH services, including that posed by climate variability and change?	Sector policy development is largely covered by DFID's support to relevant line ministries via a technical assistance project managed by Adam Smith International. Nevertheless, the FUWC does have an influencing strategy which, in particular, aims to get Freetown City Council (FCC) WASH Development Plans including an environmental sanitation sector plan and budget. Efforts should continue to focus on building CV into decision-making processes & policies, given the uncertainties around future CC.			
	Technical guidelines and	Does the programme design contribute to the development and promotion of WASH guidelines and standards which	The technical support project involves work on guidelines & standards for the MoWS and MoHS. The FUWC project is			

	standards	take adequate account of climate change?	contributing to this national level process and future influencing objectives to encourage FCC to adopt the standards developed for public toilets. In addition FUWC is developing internal guidelines & standards for members (e.g. for public toilets & tap stands), which has been a key area of work recently. Guidelines should incorporate considerations of flood risks and suggest appropriate technology options; supporting implementation to ensure best practice will also be key.			
	Monitoring	Does the programme design contribute to strong and effective systems for monitoring of water resources and WASH services?	Existing efforts to support monitoring need to be scaled-up over the longer-term. *However, this falls within the remit of the technical support project, and is beyond the scope of the FUWC work*.	n.a.		
	Research and learning	Does the research / learning component of the programme include areas related to CC?	There is no distinct research or learning component in the programme, but learning is integrated across many activities including DRR-related activities of relevance to climate risk reduction.			
	Capacity development	Does the programme include a significant component of general and CC-specific capacity development, addressing the needs of WASH service users, local Government, private sector, NGOs, central Government and development partners?	FUWC Phase II inception report documents two areas of capacity development (neither climate-specific): (i) environmental sanitation, with focus on relevant institutions & community level organisations, and (ii) planning & coordination, with a focus on FCC, RWMC, District Health Management Team, and GVWC. Capacity building at all levels is an on-going priority.			
	Flexibility and responsiveness	Does the programme contribute to the strengthening of flexible national and local planning, budgeting and emergency response capabilities which can effectively respond to gradual and rapid onset change?	The FUWC is programme contains a significant component of DRR work, such as supporting the establishment of a Freetown cholera preparedness plan and community flood preparedness. Ex-ante disaster-risk management has potential synergies with climate adaptation i.e. these could be considered low-regrets measures.			
Design and implementation	Overall design philosophy	In general how does the design of physical infrastructure in the programme take account of climate variability and change?	CV is taken into consideration during works, because it is so extreme and cannot be ignored. Areas of focus are mostly run-off, drainage and where pipes are laid. Anecdotally, local information is gathered during project planning but is difficult to apply consistently. Climate change is likely to manifest itself mostly as increased variability, so dealing with extremes will become increasingly important.			
	Catchment and source protection	Does the programme include adequate measures for source and catchment protection?	Catchment protection is certainly an issue in peri-urban Freetown. The performance of gravity schemes installed by FUWC has been hampered by deforestation & population			

			growth. The prevailing view is that little can be done to prevent this in the current policy environment. However, there are some measures for catchment protection in the WRM bill which is currently going through parliament, which will give some legal basis to possible future enforcement.	
	Impact of major abstractors on local water availability	Does the programme take due account of the indirect impacts of climate change and other socio-economic and demographic trends on WASH, especially those felt through (increasing) agricultural, industrial and urban water abstractions?	It is recognised that access to urban water in a water supply system that is both in poor repair and is too small for the (growing) population being served – this is part of the rationale for the project.	
	Water supply system design and construction	How does the design and construction of water source works take account of present and future variability of water levels and / or flows? Does the sizing of service reservoirs and larger water storage structures take due account of projected changes in the timing and magnitude of available flows? How is the design of piped distribution systems informed by climate considerations? How does the design of water treatment systems allow for future possible changes in water quality and quantity caused or contributed by climate change? Does the selection of water lifting technology allow for future increases in fossil fuel energy costs? Is there a preference for renewable energy sources?	*This project is not addressing such issues.*	n.a
	Sanitation system design	Does the programme design include modifications to latrines and other on-site sanitation technologies to reduce their vulnerability to floods? In any urban sanitation components of the programme, is due attention being paid to stormwater drainage and solid waste management? How does this address the possibility of higher flood flows in future? How does the design of sewage conveyance and wastewater treatment allow for future climate changes which affect quality and quantity of discharges?	Various modifications to latrines are undertaken in flood-prone areas, such as reinforced sub-structures and raised pits. Regarding poor solid waste management (a key contributor to flooding), there is little regulation in the city. The project has an important component addressing solid and liquid waste management. Environmental sanitation is also a focus of advocacy activities.	

For the purposes of the **Step 2** of the assessment the focus is on DFID Sierra Leone's new urban WASH component (DFID, 2013) as the DFID Malawi and Tanzania WASH programmes are both rural in emphasis. Findings are again tentative.

Understanding climate impacts

It is difficult for implementing organisations to have a strong understanding of **current variability** because the availability of hydro-meteorological data for Sierra Leone is extremely limited. Programme design does consider existing variability in the sense that plans account for the regular flooding that occurs in Freetown's informal settlements. However, given 'formal' data constraints, information is restricted to that provided by local people - for example floodwater lines on people's houses are used as indicators. **Climate change**, as opposed to variability, is less of a discussion point in the urban WASH sector. Given the high level of uncertainty (and relatively small magnitude of change) associated with climate projections, future population growth and density are considered to be more pressing issues.

Developing capacity and enhancing the enabling environment

Sector policy development is largely covered by DFID's support to the MoW and MoHS via the technical assistance component of the WASH programme. The national water and sanitation policy was approved in January 2011, but has little climate focus. The environmental sanitation policy is still under review – representing an opportunity to better incorporate climate-related risks. DFID also supports the Freetown Urban Wash Consortium (FUWC) which has an influencing strategy and, in particular, aims to ensure that Freetown City Council (FCC) WASH Development Plans include an environmental sanitation sector plan and budget. Efforts will continue to focus on building climate variability into decision-making processes and policies, given the uncertainties around future climate change.

DFID Sierra Leone's technical support project involves some work on **guidelines and standards** for the MoWS and MoHS, including urban WASH. The FUWC project is contributing to this national level process in addition to the development of internal guidelines and standards for FUWC members (such as for public toilets and tap stands), which has recently been a key area of work. Future influencing objectives are to encourage Freetown City Council to adopt the guidelines developed for public toilets. Guidelines should ideally incorporate consideration of flood risk and suggest appropriate technology options. Supporting implementation will also be key.

Stakeholders highlighted concerns about the lack of **hydro-meteorological data** and uncertainties around basic trends - whether rainfall is increasing or decreasing, or what is happening to groundwater or surface water. This makes planning for climate risks extremely difficult. Although not part of the FUWC component, support to national **hydro-meteorological monitoring** is being provided through other elements of the DFID WASH programme (including pilot work in the Rokel river basin), and to some extent by UNDP and the UK Meteorological Office. Provided that capacity building efforts continue, routine data collection and dissemination over the longer term, combined with increased coverage of monitoring stations and improved equipment, can help build the evidence base.

There is no distinct **research or learning** component in the FUWC project, and although learning is integrated across many activities they are not directly related to climate change. The FUWC Phase 2 inception report documents two areas for **capacity development**, neither of which are climate-specific but are nonetheless relevant to building resilience: firstly on environmental sanitation, with a focus on relevant government institutions and community level organisations; and secondly planning and coordination, with a focus on FCC, Freetown Waste Management Company, District Health Management Team and Guma Valley Water Company. Given Sierra Leone's post-conflict situation, capacity building at all levels is clearly a short, medium and long-term priority.

Finally, the FUWC programme contains a small but significant component of **disaster-risk management** work, including support for the establishment of a Freetown cholera preparedness plan and community flood preparedness. Disaster-risk management has clear links with climate adaptation.

Design and implementation

According to the stakeholders interviewed, climate variability is taken into consideration in **project design and construction** because of the risks it already presents. Areas of focus for urban WASH mostly concern run-off and drainage and the siting of pipes. Anecdotally, local information is gathered during project planning, for example infrastructure is designed to withstand the highest flood levels local people can remember from the past ten years. However, this is difficult to apply consistently. Future change is not considered, though arguably this is of low priority given the impact of existing variability.

In terms of improved **sanitation** and the use of resilient **technologies**, various modifications to latrines are undertaken in flood-prone areas, such as reinforced sub-structures and raised pits. Nevertheless, poor solid waste management is a key issue particularly with regards to flooding and there is little regulation in the city. Environmental sanitation is a focus of FUWC advocacy activities.

Catchment protection is a certainly an issue in peri-urban Freetown. The performance of gravity schemes installed by FUWC has been hampered by deforestation and population growth (the latter possibly driven by migration due to water availability). The prevailing view is that little can be done to prevent this in the current policy environment. On the positive side, there are some measures for catchment protection in the water resources management (WRM) bill currently going through parliament, which will give some legal basis to possible natural resource management efforts in future.

Adaptation options

Key informants identified a number of *potential* adaptation options for different WASH subsectors. This is a long-list from which some of the most relevant options (in bold) have been prioritised for economic analysis.

Water resources management and disaster preparedness

- **Flood risk mapping - identifying vulnerable areas and people**
- Flood control through dams and canals
- Strengthening government emergency preparedness and response
- Community emergency preparedness e.g. training activities
- Development of early warning systems
- Building capacity of city councils to do integrated urban planning
- Better enforcement of infringement of existing City Council by-laws around illegal connections and solid waste dumping

Water supply

- Research and build on indigenous adaptation measures e.g. simple dugout dams
- Improvement of data collection and management (ground water, surface water and rainfall)
- Use solar powered pumps instead of diesel
- Tackle flooding and landslides and dam siltation through catchment protection activities
- Improve capacity of water service providers to reduce non-revenue water, to reduce shortages in dry season
- Avoid shallow wells and use sealed boreholes instead

- Disseminate standards for wells to tackle poor siting, timing and depth
- Regulations to enforce standards for wells - councils and private sector don't have capacity
- Ongoing monitoring and evaluation to understand drivers of non-functionality, building on the Water Point Mapping initiative
- **Rainwater harvesting** - both **simple technologies for poor areas** and promotion of more complex options for richer areas - to reduce strain on water supply systems

Sanitation

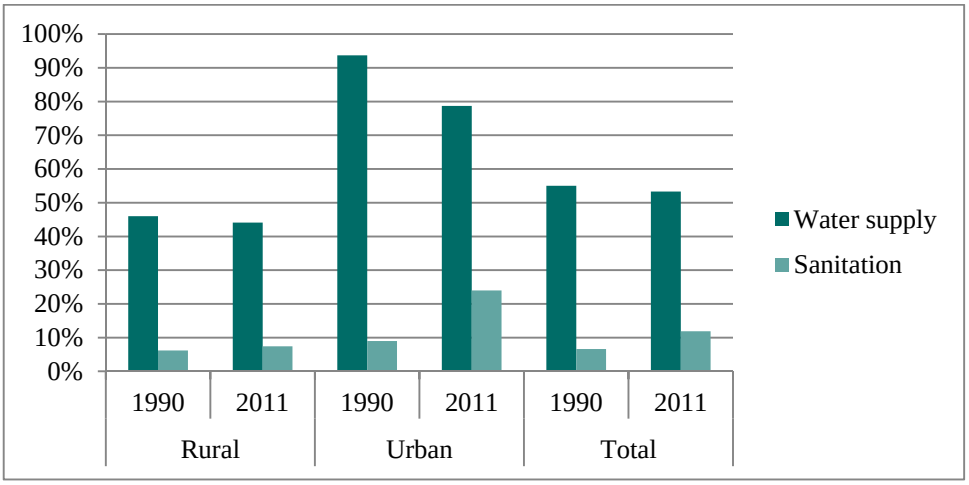
- **Literature review and dissemination of guidance note on latrine technologies for high water table areas**
- Environmental sanitation policy review
- New lagoon outside Freetown for faecal sludge
- Storm water drainage infrastructure
- **Smaller above-ground chamber toilets to allow regular de-sludging**
- Mapping urban drainage systems

4 Tanzania case study

4.1. Country context

Tanzania is a relatively large country with a rapidly growing population. The country is predominantly rural at present, but by 2050 the population is projected to be over 50% urban, and Dar es Salaam is expected to become a mega-city even sooner (over 10 million people by 2040) (GCAP, 2011). Although Tanzania is not considered water scarce - renewable water resources per capita being 2,291m³ - by 2015 it could be, due to demographic change (Noel, n.d.). Water is critical to Tanzania's economy, underpinning the agriculture sector, hydropower generation, the ecosystems of national parks and protected areas (key to the tourist sector), as well as human health and well-being (MoWLD, 2002).

Figure 3: WASH coverage in Tanzania



Source: JMP estimates (WHO/UNICEF, 2013)

Tanzania is currently not on track to meet the Millennium Development Goals for water and sanitation. In fact the latest JMP estimates show a decline in access to improved **water supply**, particularly in urban areas where access has fallen from 94% in 1990 to 79% in 2011 (WHO/UNICEF, 2013; Figure 3). In rural areas access is well below 50%. Meanwhile, although **sanitation** shows an upward trend coverage remains very low (*ibid.*). To some extent these trends may reflect the difficult transition the sector has made in the past decade from projects to programmatic support (AMCOW et al. 2010b).

The WASH sector in Tanzania has undergone reforms since the 1990s, which led to the Water Sector Development Strategy (2006-2015) and the Water Sector Development Programme (WSDP) covering rural and urban water supply and sanitation, water resources management and institutional capacity building. Although the WSDP has helped to increase coordination between different actors and attracted increased financing to the sector, there are a number of governance issues remaining. For example, financial management systems still have some major problems and money has not always been allocated to areas where there is the most need, often being based on political considerations meaning underserved areas are neglected (DFID Tanzania, n.d.a; see also MoW, 2013). In the past urban areas have been allocated 60% or more of the budget, despite most of the population being rural. Local politics can also have an influence on how resources are allocated at district level,

with some villages continuing to attract resources despite having sufficient water points (DFID Tanzania, n.d.a).

Urban water supplies in unplanned settings are the responsibility of commercial water utilities, although the limited extent and poor functioning of networks mean that many people use private vendors and water quality is often unregulated (expert interviews). Waste water treatment is also very limited in urban areas, for example there are about eight collection points in Dar es Salaam but only one or two are functioning. Key informants stated that drainage and sewerage systems are outdated and poorly maintained and, particularly unplanned settlements, people rely primarily on make-shift latrines.

In **rural areas** Local Government Authorities (LGAs) deliver services while communities are mandated to manage and operate water schemes. The implementation capacity of LGAs to deliver services is still low and although community-owned water user associations are being established and trained, legal registration has not kept pace with their creation (DFID Tanzania, n.d.a). Moreover, in the past some communities have opted for more expensive technologies than necessary and maintenance has been poor. Sustainability of rural water supply remains a challenge with around 20% of water points breaking down within two years of installation due to lack of funds, inappropriate technology, wells drying up and lack of technical support (TAWASANET, 2011). Sanitation is based on self-supply[10], thus the national sanitation campaign focusses its activities on communication, training, promotion and sanitation marketing. To date the subsector receives relatively little funding and public awareness of the benefits of improved sanitation is low (DFID Tanzania, n.d.a).

DFID Tanzania's WASH portfolio

DFID is providing £30 million from 2012 to 2015 in support of the government of Tanzania's Water Sector Development Programme (WSDP) through a pooled (basket) funding mechanism, with the intention to scale up to an additional £150 million from 2013 to 2018 through a results-based financing arrangement. In light of the current bias of funding allocations towards urban areas, DFID Tanzania has decided to earmark its contributions for rural WASH. The programme has three main components:

- **Water supply infrastructure:** Funding through LGAs to rehabilitate existing water schemes and construct new schemes, including support (training) for the establishment of community-based Water User Associations (WUAs). The construction itself would be carried out by the private sector.
- **Sanitation and hygiene:** Funding for the National Sanitation Campaign covering all 132 LGAs. In addition to promotional activities (described above) this will include training for masons in constructing and selling household sanitation platforms (sanplats) and construction of hand washing and sanitation facilities in schools.
- **Management support:** This includes training for key staff at ministry and district levels on programme management and implementation, capacity building in the private sector, capacity building at LGA level, training on gender awareness, and the recruitment of a consultancy firm to support the Ministry of Water and Prime Minister's Office (Regional Administration and Local Government) on rural WASH.

In addition to WSDP support, DFID Tanzania is working with the Ministry of Water to develop a sector climate change action plan which will help to identify specific activities to fund. They are also supporting the development of climate action plans for agriculture, energy and urban sectors. Furthermore, DFID is putting £5 million towards a first phase of 'climate-proofing' its investments in the Southern Agricultural Growth

[10] Households are expected to bear the costs of providing sanitation facilities themselves

Corridor of Tanzania (SAGCOT). The first project phase will support hydro-meteorological data generation and institutional strengthening on water resources management in the Rufiji River Basin, with a view to securing significant additional funds from the UK Climate Investment Fund (CIF) for water security infrastructure development. DFID has previously commissioned a report on the economics of climate change in Tanzania which highlights an urgent need to scale-up financing for adaptation (see box below).

Source: DFID Tanzania (n.d. a,b&c) supplemented by in-country consultations

4.2. Climate trends and projections

Tanzania lies in East Africa just south of the Equator and has a tropical climate. The country is mostly highlands with a narrow coastal strip, the coastal areas being warmer and more humid. The climate is characterised by both spatial and temporal variability. North and East Tanzania have two rainy seasons - the 'short' rains from October to December and 'long' rains from March until May. Meanwhile the Southern, Western and Central regions of Tanzania have one rainy season lasting from October to April or May. High inter-annual variability of rainfall means that the rains can be difficult to predict and there is a risk of floods and drought in some regions (McSweeney et al., 2010c).

The data show that temperatures are on the increase in Tanzania, having risen by 1.0°C since 1960, and observations of rainfall shows statistically significant decreasing trends in annual rainfall (3.3% decrease per decade on average) (McSweeney et al., 2010c). In future average temperatures will continue to rise (by 1.5-4.5°C by 2090s) as will the number of hot days and nights, the magnitude of change depending on emissions scenarios. Rainfall projections are broadly consistent in indicating an increase in average annual rainfall[11] but seasonal patterns of change are more complex. For example, in the June-September period rainfall is expected to increase in the very north but decrease in southern and central regions of the country (*ibid*.). In general the pattern suggests increases in rainfall during the wet season.[12] Heavy rainfall events are also expected to become more common and more intense, increasing runoff and the risk of flooding.

4.3. Preliminary findings of the risk assessment

As in Malawi and Sierra Leone, **Step 1** of the risks screening process suggested that other pressures on resources and services may be more important to Tanzania's development trajectory than climate change *per se*. For example, rapid population growth and urbanisation is increasing demand for water and the production of faecal sludge and solid waste, and pressure on natural resources is leading to environmental degradation. The lack of hydrological monitoring networks and data has also been identified as a key challenge by stakeholders, hindering effective WASH and WRM planning. Moreover, the lack of institutional capacity for implementation and management, particularly at local level (LGAs, private sector and among communities), remains a bottleneck for rural WASH and natural resources management. To date attention in Tanzania's WASH sector has focused on new infrastructure rather than recurrent costs or capacity building needs. Finally, several

[11] Some models predict a slight decrease.

[12] GCAP (2011) also suggest that rainfall projections indicate a seasonal shift, with weaker early season rains and stronger late season rains, but the authors are careful to note the significant uncertainty involved and disagreement between climate models.

stakeholders highlighted the need to consider WASH in the context of integrated water resources management (IWRM).

Accepting that climate change may not be *the most* important issue to consider, research has nevertheless shown that at national level climate risks place a significant burden on Tanzania's economy, constraining economic growth (see box below). Furthermore, climate variability already poses a challenge in certain regions or locations that are exposed to flood risks or drought. With future increases in heavy rainfall events, coupled with land degradation and poor drainage, high runoff and flooding may be exacerbated with implications for WASH infrastructure and the quality and quantity of water available.

The economics of climate change in Tanzania

A study was commissioned by DFID to assess the impacts and economic costs of climate change in Tanzania, the costs and benefits of adaptation and the potential for low carbon growth.

In the past, climate variability has exacted a heavy economic burden due to the country's dependency on climate sensitive activities, particularly rainfed agriculture, and periodic droughts and floods have caused major socio-economic impacts and reduced economic growth. For example, the 2005/6 drought affected millions of people and had a cost of at least 1% of GDP. In short, Tanzania is not well-equipped to deal with existing climate risks. Future costs are much more uncertain but climate variability and change could incur losses of 1.5-2% of GDP/year by 2013.

"The combined and cumulative effects of current climate variability and future climate change are large enough to reduce the chances of Tanzania achieving key economic and development targets and challenging the timetable for achieving middle income status."

The funding required to mitigate these climate-related costs is considerable. Immediate needs (for 2012) to build adaptive capacity and address priorities are estimated at USD100-150 million/year, whereas the medium-term costs are of the order of USD250-1000 million/year by 2030.

Source: summarised from GCAP (2011)

Table 5: Sector level risk assessment for Tanzania

NB. Scores are presented for a number of quantitative and qualitative indicators. The former are based on publically available data sets (refer to the guidance in Appendix B, main report). Note that the latter are based primarily on key documents and in-country discussions but have not been subjected to detailed analysis by key stakeholders and so should be considered provisional.

		Score					
No	**Factor**	**1**	**2**	**3**	**4**	**5**	**Comments**
1.1	Government effectiveness						Tanzania ranks in the 25-50 percentile according to this indicator.
1.2	WASH and other policies						The WASH sector has good policies, reflected in the WSDP. (The challenge is implementation.)
1.3	WASH institutional capacity						Local government capacity is low, particularly in rural areas – a major bottleneck for implementation.
1.4	Cross-sector & trans-boundary cooperation						Cross-sector coordination exists on paper, but is weak in practice.
2.1	GNI per capita						As a least developed country Tanzania scores 1 on this indicator.
2.2	WASH and national budget						WASH represented less than 2% of the Tanzania national budget in 2011 according to WASHWatch.
2.3	Adequacy of WASH recurrent budget						Lack of adequate budget for recurrent costs, emergency response budgets also limited.
3.1	Technology						The dominant water supply technology is boreholes (mostly motorized pumps), considered to be relatively resilient to CC. But problems relating to O&M put these technologies at higher risk of breakdown and hence to climate-related shocks.
3.2	Design & construction standards						Standards for best practice exist and guidelines are fairly comprehensive.
3.3	Standards observed - implementation						Enforcement is weak.
4.1	Monitoring agencies						National met office seems fairly strong, but weak capacity in MoW for hydrological monitoring.
4.2	Monitoring networks						Meteorological and hydrological (including groundwater) networks exist, but maintenance is a challenge. Stations are few given the size on the country.
4.3	Environmental data						General lack of routine data collection and analysis. Large gaps in meteorological data (15-20 years) and limited hydrological data.
5.1	National population growth						Population is projected to grow by roughly 2.5-3% per year from 2010 and 2050.
5.2	Urban population growth						Urban population is projected to grow by >4% per year from 2010 and 2050.
5.3	Deforestation and env. damage						Environmental degradation is identified as a key issue in policy documents.
6.1	Mean rainfall change						Median projection 6mm by 2060s.
6.2	Change in annual 5-day max rainfall						Median projection 3% change by 2030s
6.3	Climate change impacts in general						Pockets of high risk to current variability (floods and droughts); high economic costs of climate impacts.
7.1	Human development index						Tanzania's HDI is 0.476, rank of 152 out of 187 (second quartile).
7.2	CSOs/media accountability						Tanzania's percentile rank on the World Bank score for voice and accountability is 45.

Table 6: Programme-level risk assessment – DFID support for Tanzania's WSDP

NB. The contents of this table are provisional and subject to consensus from the relevant experts. We would emphasise that the indicators are a measure of programme risk rather than programme quality. Many of these factors are strongly influenced by what is going on in the rest of the sector, and not within the control of programme stakeholders. It is quite conceivable that an excellent programme could receive a sea of red scores simply because it is taking place in the context of large risks, or because it is may be very difficult or beyond the scope of the programme to address those areas under current circumstances. Nevertheless, the programme should arguably be doing all that is possible to address the most important risks.

				Score		
Aspect	**Element**	**Question**	**Response and proposed actions**			
Understanding of climate impacts	Present climate	Is there good understanding among all stakeholders of existing climate variability, its impacts on water resources and its implications for WASH services?	DFID Tanzania has relatively strong capacity for climate risk assessments, with a dedicated CC advisor. Sector stakeholders generally understood that CV and CC pose a threat to WASH services, particularly in relation to WRM & urban flooding. There was perhaps less understanding of how to integrate climate risks into everyday WASH planning and implementation. Hydro-meteorological data should be used to inform planning.			
	Future climate	Is there good understanding among all stakeholders of projected climate change, its likely impacts on water resources and its implications for WASH services?				
Developing capacity, enhancing the enabling environment	WASH policies	Does the programme design contribute to the development and promotion of strong sector policies which recognize the multiple pressures on WASH services, including that posed by climate variability and change?	There is no explicit reference to CC in the national WASH policy. IWRM and catchment management relevant, but there is a big gap in implementation - action is needed to strengthen cross-sectoral linkages. CC is considered to some extent in the WRM component of WSDP (but in practice there has been little action). A CC action plan for water sector is under development – it will be important to ensure ownership of this plan by the ministry & integration across WSDP components.			
	Technical guidelines and standards	Does the programme design contribute to the development and promotion of WASH guidelines and standards which take adequate account of climate change?	Adequate guidelines are available (although CC not addressed explicitly). CV is considered *in theory* – the problem is implementation. There is a need for capacity building at LGA level and the enforcement of best practices.			
	Monitoring	Does the programme design contribute to strong and effective systems for monitoring of water resources and WASH services?	National networks and agencies are weak and in disrepair. Hydrological data is not collected or disseminated regularly. Considerable long-term investments are needed nationally for hardware (infrastructure & equipment) and software (e.g. staff levels and training) development. In recognition of this DFID is providing support to monitoring efforts in the Rufiji basin with the intention to scale up investments.			

	Research and learning	Does the research / learning component of the programme include areas related to CC?	WSDP doesn't have a research and learning component. CC research mainly funded by donors (i.e. piecemeal studies). There is some degree of collective learning through technical working groups, but often little action. Learning objectives need to be formalised in the WSDP.	
	Capacity development	Does the programme include a significant component of general and CC-specific capacity development, addressing the needs of WASH service users, local Government, private sector, NGOs, central Government and development partners?	WSDP includes capacity building as one of four main components but lacks clarity on implementation. Human resources development needs to be approached systematically. Training should incorporate e.g. how to utilise hydro-meteorological information and incorporate climate (and other) risks in every-day planning processes.	
	Flexibility and responsiveness	Does the programme contribute to the strengthening of flexible national and local planning, budgeting and emergency response capabilities which can effectively respond to gradual and rapid onset change?	There is some 'learning by doing' in WSDP e.g. Phase 2 will be shaped based on experiences implementing Phase 1. Mechanisms are needed to ensure that data on climate and other risks feed into programme design at regular intervals. Budgets for emergency responses are limited.	
Design and implementation	Overall design philosophy	In general how does the design of physical infrastructure in the programme take account of climate variability and change?	Climate change is not considered when designing WASH infrastructure or selecting technology options, although feasibility studies should (in theory) account for current climate risks it is unclear whether this is practiced.	
	Catchment and source protection	Does the programme include adequate measures for source and catchment protection?	Catchment protection was highlighted as a key issue. Institutions are in place but budgets for implementation are inadequate. Additional funds are needed to support IWRM and catchment protection. There is also a need to investigate the root causes of degradation and assess the opportunities and trade-offs (for households) associated with different interventions.	
	Impact of major abstractors on local water availability	Does the programme take due account of the indirect impacts of climate change and other socio-economic and demographic trends on WASH, especially those felt through (increasing) agricultural, industrial and urban water abstractions?	Increasing abstraction is due to irrigation expansion, particularly, and the growth of urban areas such as Dar es Salaam. This is more relevant for WRM component of WSDP and SAGCOT programme, but has potential implications for WASH. Better linkages between WRM & WASH are needed.	
	Water supply system design and construction	How does the design and construction of water source works take account of present and future variability of water levels and / or flows? Does the sizing of service reservoirs and larger water storage structures take due account of projected changes in the timing and magnitude of available flows? How is the design of piped distribution systems informed by climate considerations? How does the design of water treatment systems allow for future possible	Community technology choices are not always the most suitable; it is not clear why certain technologies are chosen over others, or whether climate variability (e.g. drought/flood risk) is accounted for in practice. Most rural water supply schemes use motorised pumped which could be resilient (in theory) but are costly to run and difficult for communities to manage. The use of these systems is constrained by inadequate supply chain, and the lack of skills and	

		changes in water quality and quantity caused or contributed by climate change? Does the selection of water lifting technology allow for future increases in fossil fuel energy costs? Is there a preference for renewable energy sources?	knowledge to install, operate and maintain such schemes. In addition to tackling these issues, there is a need to ensure that guidance is available to practitioners on existing climate risks and technology choices, and that best practices are enforced. There is huge potential to use renewable energy e.g. solar systems to reduce carbon emissions and operation and maintenance costs. Solar and wind power used in some locations, but technologies are not readily available.		
	Sanitation system design	Does the programme design include modifications to latrines and other on-site sanitation technologies to reduce their vulnerability to floods? In any urban sanitation components of the programme, is due attention being paid to stormwater drainage and solid waste management? How does this address the possibility of higher flood flows in future? How does the design of sewage conveyance and wastewater treatment allow for future climate changes which affect quality and quantity of discharges?	Functional drainage and waste water treatment systems (urban) and improved sanitation facilities (rural and urban) are severely lacking. Flooding is a major health hazard. The first step is to tackle the existing deficit in improved sanitation coverage. It may be necessary to provide financial support to communities/HH most at risk e.g. to upgrade latrine design in flood prone areas or re-build latrines following collapse during flooding events. Increased attention is also needed for maintenance and upgrading/expansion of urban systems. (NB. this falls outside DFID's current remit - the rural component of WSDP.)		

Given that DFID's current approach to delivering on WASH in Tanzania is sector budget support to WSDP, in **Step 2** we decided to assess the WSDP as a whole, considering water and sanitation issues, rural and urban contexts, and WRM. However, there is some bias in focus towards rural water and sanitation as DFID funds are earmarked for this component of the national programme.

Understanding climate impacts

Several stakeholders suggested that climate risks were relatively low and location-specific in Tanzania as compared to other East African countries such as Ethiopia. Nevertheless, it was generally understood that climate variability and change posed a threat to WASH services, particularly in relation to water resources management (and in urban areas, waste and storm water management). As in Malawi, there is some awareness of the general risks but a lack of detailed understanding of how to integrate climate risks into WASH planning and implementation. Although data are available from the national meteorological office (on a cost sharing basis), it is unclear whether the WASH sector makes regular use of this data in designing projects or programmes. The analysis of impacts on specific WASH subsectors is also made difficult by the wide variation in climate projections, and this uncertainty may hinder concrete responses.

Developing capacity and enhancing the enabling environment

Whilst there is no explicit reference to climate change, it has been argued that national **WASH policy** prescriptions are compatible with a national climate change response, for example addressing IWRM and catchment management. However, key informants felt that more could be done to strengthen links between WASH and IWRM. The Ministry of Water has commissioned the development of the Integrated Water Resources Management and Development (IWRMD) plans across nine river basins. Plans are expected to provide an up to date assessment of baseline and future supply-demand balances for different sectors and water users in the basins. However, implementation of plans will require long term institutional capacity strengthening and support.

The **WSDP programme** as a whole is comprehensive and has been designed based on best practice for the sector. Climate change is considered to some extent in the WRM component (although in practice little has been done to date), yet there is little explicit consideration of climate risks in other programme components. In general WASH activities are not currently planned with climate change in mind. A climate change action plan for the agriculture sector is currently under development with DFID support and other donors are currently exploring the possibility of supporting a similar initiative for the water sector. Assuming the latter goes ahead, it will be important to ensure ownership of this plan by the ministry, particularly the WSDP steering and technical working groups, as well as integration across WSDP components.

Both DFID and government staff thought that adequate **guidelines** for WASH practitioners and contractors were available, although climate change may not be explicitly considered[13]. In theory feasibility studies should be conducted before implementation as a matter of routine, including consideration of flood and drought risks. The key issue is lack of LGA capacity for monitoring and enforcement of best practice standards. In addition to capacity building and promotion of best practices, development actors can play a role in ensuring that technical guidelines are updated to include explicit consideration of climate-related risks.

With the exception of the Tanzanian Meteorological Agency which collects and disseminates climate data, **hydro-meteorological monitoring** networks and agencies in Tanzania are fairly weak, and data on surface water and groundwater are not routinely collected or disseminated. Recognising this challenge, DFID is already providing some

[13] The National Sanitation Options and Construction Guidelines (MoHSW) do not mention the risk of floods, although there is a chapter on providing emergency sanitation facilities.

support in the Rufiji river basin to strengthen the hydrological monitoring network and institutions for water management, with the potential to scale up with funding from the UK Climate Investments Fund. DFID is also considering how best to incentivise better monitoring (e.g. of water point functionality) in the next tranche of funding for WSDP using a results-based financing approach. In short, it is likely that considerable long-term investment is needed to rehabilitate monitoring facilities, update equipment and expand the network. The 'software' will be equally important, including the recruitment and training of staff.

At present the WSDP does not include a **research and learning** component, and climate change research is mainly funded by donors through *ad hoc* studies. There is some degree of collective learning as technical working groups meet to discuss issues, but action points are not always followed up on. Learning objectives may need to be formalised in the WSDP, particularly in the next few years once implementation is fully underway. Technical assistance may be needed in articulating research and learning needs on climate change and WASH specifically.

The WSDP includes **capacity building** as one of four main components but the Phase 1 evaluation (MoW, 2013) found that, to date, there has been a lack of clarity as to how this will be implemented. Human resources development needs to be approached systematically and with capacity building interventions integrated into the work plans and budgets of the three 'technical' components of WSDP (*ibid*.). The evaluation also highlighted the need for training in the analysis and use of hydro meteorological information.

In terms of **flexibility and responsiveness**, tentative findings suggested some degree of collective 'learning by doing' in the WSDP, with Phase 2 of the programme informed by the experience of implementing Phase 1. Nevertheless, there is a need to ensure that information on climate and other risks (e.g. population, environmental degradation) feeds into programme design at regular intervals – building in mechanisms for data uptake. Budgets for emergency response are also limited, but perhaps a bigger issue for WASH is the lack of funds to cover recurrent costs.

Design and implementation

The extent to which climate variability and change are factored into the **design of WASH infrastructure** and the selection of technology options was discussed with stakeholders but remains unclear. The general approach to rural water supply in Tanzania is demand-led design, yet the tendency to date under the WSDP has been for communities to select higher-cost options which are not always affordable over the longer term. In theory, the menu of options offered under demand-led approaches should be shaped by an understanding of resource conditions, trends and climate risks, and certainly those related to existing levels of climate variability.

Catchment protection was repeatedly highlighted by stakeholders as a key issue for sustainability of surface and groundwater sources and the mitigation of flood risk. Institutions are in place in Tanzania, but budgets for implementation are thought to be inadequate. Donors could consider providing additional funds for WASH-related catchment protection under the IWRM component of WSDP. The next phase of DFID support for 'climate proofing' SAGCOT through WRM infrastructure development could perhaps provide an opportunity for investment in catchment protection.

Functional **drainage and waste water** treatment systems (urban) and improved **sanitation** facilities (rural and urban) are severely lacking in Tanzania. Consequently flooding is a major health hazard, destroying poorly built latrines and leading to contamination of surface water from sewerage, contributing to outbreaks of cholera and other water-related diseases. An obvious first step is to tackle the existing deficit in improved sanitation coverage, yet some immediate climate-specific actions can also be taken to increase resilience. For example, targeted support (financial or other) could be provided to communities or

households most at risk of flooding to enable them to upgrade their latrines in flood-prone areas or re-build latrines following collapse. Some support is already provided by communities themselves through community action plans which target vulnerable individuals such as the elderly, disabled or people living with HIV/AIDS. In urban settings, the maintenance and upgrade of existing systems, alongside expansion of the network to cover newly settled areas, are priorities.

Adaptation options

A number of potential adaptation options were identified by stakeholders in the Tanzanian workshop. Again, this is a long-list and not all will be relevant nationally. Some options are highly context specific; several are focused on urban areas, which is not currently relevant to DFID Tanzania's WASH programme. Those highlighted in bold have been developed further for the economic analysis (see Section 3 of the main report).

Water resources management:

- Improve surface water and groundwater monitoring and data collection
- **Catchment protection**
  - Opportunity costs of catchment protection (e.g. can't collect firewood)
  - Investigate root causes of degradation e.g. deforestation, maybe intervention is efficient cook stoves
  - Flood control via soil water conservation
- Community-based WRM and conflict management – capacity building
- **Natural and artificial groundwater recharge (training for local government staff)**
- Better water storage/flood control - dual purpose of preventing damage to infrastructure and capturing flood water (e.g. for use during dry periods)

Water supply:

- Multiple-use services
- Spread risk by having multiple rural water supply options (back-up supply) – augmenting options, surface water and groundwater
- Rainwater harvesting
- Water re-use
- **Proper supervision of construction and drilling boreholes to the bottom of the aquifer**
- Post-construction support
- Demand management in urban water supplies

Sanitation & drainage:

- Maintaining and extending urban sewerage and drainage systems
  - Improving sewage and waste water management
  - Awareness raising (clean-up day)
  - Install drainage in unplanned settlements
- Improved urban planning and governance
- Possible use of waste for energy (rural sanitation)
- Compare traditional collapsing latrine with lined pit with bricks
- **Public education around sanitation and flood risks**

5 Emerging issues

Malawi, Sierra Leone and Tanzania are all making progress on WASH, albeit from very different positions. All three countries are vulnerable to existing climate variability and change, though the direction and magnitude of future changes in rainfall remain uncertain. What is clear is that existing variability already affects the performance of WASH, and there is interest in understanding what more could be done to secure WASH results and safeguard hard-won benefits.

In terms of urban WASH service delivery, the extension of water supply and drainage networks is clearly a priority given high rates of urbanisation, alongside the use of flood-resilient technologies. Meanwhile, delivery of improved water and sanitation in rural areas through devolved government structures relies heavily on community-based operation and maintenance. The lack of adequate resources and capacities at local level, reliable supply chains for spare parts and enforcement of best practice present problems in all three countries. Indeed throughout sub-Saharan Africa, the drive for new infrastructure development has often diverted attention away from the sustainability of existing schemes, and capacity building efforts for operation and maintenance have tended to lag behind construction. Although water point mapping has been carried out in all three countries, the underlying causes of poor performance remain under-researched and poorly understood

Explicit consideration of flood and drought risk in both urban and rural WASH planning and design remains a priority. In Sierra Leone, this is being addressed through DFID-supported FUWC work. The development, use and enforcement of best practice guidelines on WASH that address climate risks, for example through better siting of water points or changes in latrine design in flood-prone areas, could increase the resilience of WASH services to climate change and other pressures.

Complicating matters is the fact that major uncertainties exist in all three countries about their climate and water futures. Data on resource conditions and trends, water withdrawals and pollution loads, the functionality of WASH services and the causes of failure are also limited. The lack of information, coupled with the inherent limitations of climate modelling, makes it difficult for decision-makers to plan for the future. Some relevant initiatives are underway to build hydro-meteorological monitoring capacity, such as the DFID Tanzania investments in the Rufiji river basin and DFID Sierra Leone support for pilot work in the Rokel river basin. Nevertheless, large uncertainties are likely to remain. In this context, robust decision-making is important, including the selection of options that are likely to perform well over a range of future scenarios. Simple risk screening exercises can provide a useful starting point for identifying ‘no’ or ‘low’ regrets interventions.

A number of the adaptation options identified by stakeholders in country consultations focussed on links between WASH and natural resources management, including catchment protection. Integrated water resource management plans implemented through river basin organisations will take many years to implement; countries such as Tanzania are making a start. At the watershed scale, however, there may be tangible opportunities to link WASH planning with soil and water conservation programmes supported (typically) through the agriculture-food security sector.

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Appendix A – Climate comparisons

Table A1: Climate trends and projections for Malawi, Sierra Leone and Tanzania

		Malawi	Sierra Leone	Tanzania
General climate	**Annual rainfall determinants**	Timing/intensity of ITCZ	Timing/intensity of West African Monsoon driven by ITCZ	Timing/intensity of ITCZ
	Inter-annual rainfall determinants	Variability of ENSO through Indian ocean surface temps	Variability of ENSO, strong ENSO causes drier West Africa	Variability of ENSO – El niño causes higher average rainfalls in short rains, La Niña means drier than average
	Wet season	Nov-Feb (into March/April in the north)	May-Oct (peaks Jul-Sep)	N&E has short rains Oct-Dec and long rains Mar-May; S&W has one wet season Oct-Apr
Recent temperature trends	**Mean annual temperature rise 1960-2006**	0.9 °C	0.8 °C	1.0 °C (esp in JF)
	Increase in 'hot' days 1960-2003	8.3%	Insufficient data	Small overall (but 8.2% in DJF)
	Increase in 'hot' nights 1960-2003	11.1%	Insufficient data (but visible trend is hot nights increasing)	13.6% (strongest in DJF)
	Decrease in 'cold' days 1960-2003	4.3%	Insufficient data	No change
	Decrease in 'cold' nights 1960-2003	8.9%	Insufficient data	9.3% (strongest in DJF)
Recent rainfall trends	**Annual rainfall trends**	No significant trends - year-to-year variability v strong,	Mean has decreased since 1960s but hard to call a trend because of variability	Significant decrease, monthly rate decreased 3.3% per decade
	% rain in heavy events	No significant trend	Insufficient data	No significant trend
Temperature projections	**Mean annual temperature rise by 2060s**	1.1 - 3.0 °C	1.0 - 2.6 °C	1.0 - 2.7 °C
	% days 'hot' (based on current) by 2060s	14-32%	26-63% (esp on coast)	19-40%
	% nights 'hot' (based on current) by 2060s	27-53%	41-79% (esp on coast)	30-68%
	% of 'cold' days/nights	All models say decrease	All models say decrease	All models say decrease
Rainfall projections	**Mean rainfall**	No significant trends, models say -13% to +32%	Models disagree, but tend towards increases	Models consistently predict increases of median +7 to +14% by 2090s
	Seasonal rainfall trends	Decreases in dry season rainfall (JJA and SON), and increases in wet season rainfall (DJF and MAM)	Clearer increases in late wet season (Aug-Oct)	Seasonal trends more complex, generally suggests increases in wet season of each region
	Trends in % of rain falling in heavy events	Models consistently project increases (esp. in wet season)	Tends towards increases, esp. in late wet season	Models consistently project increases (esp. in wet season)
	Increases 1- and 5-day rainfall	Models consistently project increases by 2090s	Tends towards increases, esp. in late wet season	Models consistently project increases by 2090s

	maxima			
Other info.		Disagreements in projected amplitude of ENSO events	Models strongly disagree on rainfall projections across W. Africa; disagreements in projected amplitude of ENSO; coastal areas vulnerable to sea-level rise	Disagreements in projected amplitude of ENSO events

Source: McSweeney et al. (2010a,b,c)

Appendix B – Stakeholders consulted

Table A2: People consulted during country visits

Name	Organisation & position
Malawi	
James Mambulu	DFID - Water & Sanitation Programme Manager
Martin Dawson	DFID - Deputy Head of Office
Teddie Nankuma	DFID - Senior Economic Adviser
Donald Reuben Kamdonyo	DFID - Climate Change Adviser
Nick Amin	DFID - Senior Economic Adviser
Modesta Banda Kanjaye	MoIWD - Director of Water Resources
Stephen Mwanza	MoIWD - Director of Water Supply
McLawrence Green Mposa	MoIWD - Director of Sanitation
James Mwenda	MoIWD - Economist
Aloysius Kamperewera	MoECCM - Director of Environmental Affairs
Mercy Masoo	WaterAid - Country Representative
Muthi Nhlema	Water for People - Grants and Documentation Manager
Louis Kawenda	Cadecom
Ken McCarthy	GOAL - Country Director
Lovemore Mvula	WaterAid - Rural Programme Officer
Jolly Ann Maulit	UNICEF - DFID Programme Coordinator
Emmanuel Chiundira	MoIWD Water Resources Department - Hydrologist
Peter Matipwiri	World Vision International - WASH Director
James Longwe	Participatory Development Initiatives - Executive Director
Hanna Chimagire	ActionAid
Tanzania	
Lukas Kwesi	DFID - Water Advisor
Magdalena Banasiak	DFID - Climate Change Advisor
Richard Moberly	DFID - Economist
Nick Highton	DFID - Economic Advisor
Herbert Kashililah	WaterAid - Technical Advisor
Godfrey Mpangala	WaterAid - Head of Water Supply
Marko Msambazi	WaterAid - Head of Sanitation
Gilbert Kajuna	USAID - Programme Manager for WASH
Susanna Pykala	UNDP - Climate Change Analyst
Falk Negrazus	GIZ
Pius Yanda	Centre for Climate Change Studies - Director, University of Dar es Salaam
Magdalena Mtenga	VPO DoE - Assistant Director (Pollution specialist)

Ir. Fanuel Kalugendo	PMO - Disaster Risk Management Expert & Civil Engineer
Elias Chinamo	MoHSW - Assistant Director, Environmental Health, Hygiene & Sanitation
Ms. Rweyemamu	MoW - Director of rural water supply
Dr Ladislaus Chang'a	TMA – IPCC Focal Point
Augustine Kanemba	TMA - Principle Meteorologist
Wilbert Timiza	TMA
Sierra Leone	
Martin Walshe	DFID - Regional infrastructure advisor
Saskia Marijnissen	UNDP - Programme Manager – Environment
Kwabena (KS) Manu	Adam Smith International (ASI) - Team Leader
Rogers Lubunga	AfDB - Principal WASH Engineer
Gillian Walker	Oxfam - Essential Services programme manager
Shumet Alemayehu	ACF - Head of Department, WASH
Maria Dillon	Oxfam - WASH Technical Assistance
Ansumana Sillah	MoHS - Environmental Health Coordinator
Hussein Hassen	Oxfam - Urban WASH Project Coordinator
Mohamed Juanah	MoWR - Head of Water Resources
Sam Goba	MoWR - Senior Hydrologist
Miatta Croquenode	MoWR - Policy Analyst
Olivia Couborough	DFID - Economist
Joseph Allie	DFID - programme manager
Victor Kinyanjui	UNCIEF - WASH Manager
Frederick Fabba	Goal - Urban WASH Programme Manager
Loretta Juorah	EPA - Environment Officer
Mamodu Bah	EPA - Acting Coordinator, CC Secretariat
Singe Day	Adam Smith International (ASI)