WASH Climate Resilient Development

Technical Brief

Local participatory water supply and climate change risk assessment: Modified water safety plans

About UNICEF

UNICEF works in more than 100 countries around the world to improve water supplies and sanitation facilities in schools and communities, and to promote safe hygiene practices. We sponsor a wide range of activities and work with many partners, including families, communities, governments and like-minded organizations. In emergencies we provide urgent relief to communities and nations threatened by disrupted water supplies and disease. All UNICEF WASH programmes were designed to contribute to the Millennium Development Goal for water and sanitation.

About GWP

The Global Water Partnership is an intergovernmental organisation of 13 Regional Water Partnerships, 85 Country Water Partnerships and more than 3,000 Partner Organisations in 172 countries. Its vision is a water secure world. Its mission is to advance governance and management of water resources for sustainable and equitable development through integrated water resources management (IWRM). IWRM is a process that promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner, without compromising the sustainability of vital ecosystems and the environment.

ISBN: 978-91-87823-09-1
Cover photo credit: © UNICEF/Bangladesh/2014
Design and layout by Scriptoria Communications, updated by Strategic Agenda.

Prepared in cooperation with HR Wallingford and the Overseas Development Institute (ODI)

Contents

Supporting climate resilience in the WASH sector

Part 1 – Purpose and description of the modified water safety plan for climate resilient water supply systems 1

1.1. Why this Technical Brief 1

1.2. What is this Technical Brief about 1

1.3. Who is this Technical Brief for 2

1.4. Modified water safety plans including environmental and climate change hazard assessment 3

Part 2 – Tasks in detail: A step-by-step approach 5

Task 1: Agree the plan, assemble a team and engage the community 5

Tasks 2a and 2b: Describe the community water supply: include water resources 5

Tasks 3a and 3b: Identify and assess hazards, hazardous events, risks and existing control measures: include environmental and climate hazard assessment 8

Tasks 4a and 4b: Develop and implement an incremental improvement plan: include consideration of climate resilient adaptation options for water supply interventions 9

Task 5: Monitor mitigation measures and verify the effectiveness of the modified water safety plan 17

Task 6: Document, review and improve all aspects of water safety plan implementation 17

References 18

Acknowledgements

Figures

Figure 1.1: ‘Modified’ water safety plan (WSP-P) approach to include environmental and climate change hazard assessment and identify climate resilient investment options for water supply and sanitation interventions 4

Figure 2.1: Factors to consider when siting a water supply system 6

Figure 2.2: Estimating the catchment area (recharge area) for a water supply 7

Figure 2.3: Environmental hazards in the vicinity of a water supply system (or of sanitation infrastructure such as latrines) may lead to direct damage to the infrastructure (e.g. through flooding or landslides). Degradation processes in the wider catchment area may lead to increased runoff and reduced groundwater recharge 8

Figure 2.4: Natural resource degradation features that might undermine the resilience of a water supply (top) and possible mitigation measures as laid out in a catchment protection plan (bottom) 10

Tables

Table 1.1: Resilience of water technologies to climate change: applicability by 2030 2

Table 2.1: Estimating the catchment area required to generate sufficient recharge to meet demand 7

Table 2.2: Possible interventions to build climate resilience 11

Supporting climate resilience in the WASH sector

This Technical Brief forms part of the Strategic Framework for WASH Climate Resilient Development, produced under a collaboration between GWP and UNICEF.[1] The Framework advances sector thinking around WASH and climate change, cutting across both development and emergency preparedness programmatic spheres; climate resilience is addressed as a cross-cutting issue encompassing elements of both disaster risk reduction and climate change adaptation.[2] It serves to set out the rationale and concepts for WASH climate resilient development, as well as improve understanding of how to ensure that climate resilience is considered in WASH strategies, plans and approaches.

The objective of the Strategic Framework is to support WASH service delivery that is resilient to the climate, both now and in the future. The Strategic Framework is centred around four quadrants of activity; this Technical Brief sits within the 'Deliver solutions' quadrant, shown in the figure below.

Strategic Framework for WASH climate resilient development

Guidance Note:
- Risk assessments for WASH

Technical Briefs:
- Linking risk with response: options for climate resilient WASH
- Appraising and prioritising options for climate resilient WASH

Technical Brief:
- Monitoring and evaluation for climate resilient WASH

Technical Briefs:
- Integrating climate resilience into national WASH strategies and plans
- Local participatory water supply and climate change risk assessment: modified water safety plans

---

[1] GWP and UNICEF (2014)

[2] http://www.gwp.org/en/we-act/themesprogrammes/Climate-Resilience/WASH-Climate-Resilient-Development-a-GWP-UNICEF-Collaboration/

Part 1 – Purpose and description of the modified water safety plan for climate resilient water supply systems

1.1 Why this Technical Brief

Access to secure water and sanitation services plays a key role in poverty reduction. However, progress in extending and sustaining services will be undermined unless investments are resilient to both existing levels of climate variability and future change. Climate change is expected to alter the distribution, timing and intensity of weather-related events[1], affecting the availability and quality of water resources, the infrastructure needed to deliver water, sanitation and hygiene (WASH), and WASH services themselves. Predicting impacts remains difficult, however, at least at the scales relevant to local decision-making. This is because rainfall projections, in particular, are uncertain. There is also a long and complex chain linking climate-related hazards on the one hand, to impacts on service quality and reliability on the other; 'drivers of change' (shifts in land use, population growth) also affect outcomes. In this context, it is important to avoid simplistic crisis narratives that suggest that climate change is the main reason for perceived increases in water scarcity and system failure.[2] In view of the uncertainties associated with climate change, it is also important to focus on planning responses that are appropriate for a range of climate conditions and trends, starting with existing (known) risks – especially those associated with floods and droughts.

This Technical Brief therefore addresses the need for WASH planning that is 'robust to uncertainty', outlining a participatory approach to ensuring more resilient, community-based rural water supplies. Working with and alongside implementing agencies, such as local government bureaux and non-governmental organisations (NGOs), this approach is designed to help communities build and manage systems that prevent or mitigate risks to water quality, reliability and infrastructure. Drawing on the *Strategic Framework for WASH Climate Resilient Development*,[3] the aim is to strengthen *existing* guidance on WASH planning, not to supplant it. The approach, therefore, builds on an existing and widely adopted Water Safety Plan (WSP) framework, originally developed to assess and mitigate risks to water quality and health (Box 1).[4] The modified framework is referred to as **WSP-Plus** (WSP-P), and extends the concept of safety to incorporate provision of safe supply as well as safe quality.

1.2 What is this Technical Brief about

This Technical Brief focuses on community-managed water systems[5] that draw water from shallow aquifers, or "system(s) used by the community to collect, treat, store and distribute drinking-water from source to consumer".[6] User-managed water supplies[7] based on small springs and wells are typically (though not always) more vulnerable to climate-related hazards than, for example, deep boreholes. Post-construction field surveys and monitoring programmes often highlight problems with the seasonal drying-up of shallow wells, and problems with flooding-related contamination from on-site sanitation.[8]

Specifically, this Technical Brief focuses on:

- **Small-scale, low-cost, low-tech community managed systems** (managed 'at the lowest decentralised level') found in many African, Asian, Latin American and Caribbean countries, with an anticipated design life of 10-30 years
- **Rural areas**, where the majority of poorer people still live, while acknowledging the growing need to apply broader risk screening approaches, based on WSPs, in expanding peri-urban and urban areas
- **Managing risks**, starting with the identification of hazards that include: changing rainfall patterns, increasing frequency and intensity of droughts and floods, and seawater intrusion (see Table 1.1 and the *Strategic Framework for WASH Climate Resilient Development*[9] for further details on climate change and environmental hazards relating to WASH services).

It is important to mention that this Technical Brief does <u>not</u> deal with higher order issues: those hazards arising from the behaviour/practices of actors beyond

---

[1] IPCC, 2014
[2] Calow et al., 2011
[3] GWP and UNICEF, 2014
[4] WHO, 2005
[5] Those systems where users of the water retain sole responsibility for operation and management of the supply and do not transfer responsibility to a third party
[6] WHO, 2012
[7] Such as shallow dug wells, protected springs, manually and mechanically drilled shallow wells, and piped networks operated by communities or user groups
[8] WHO, 2012; Oates et al., 2014
[9] GWP and UNICEF, 2014

the watershed/community already considered within conventional WSPs. In addition, the note does not elaborate on the public health and broader livelihood benefits that could be expected to arise from more climate resilient systems and services. Finally, the focus on simple, community-based water systems means that the full spectrum of adaptation options for WASH are not considered. Gaps, for example around sanitation and hygiene interventions, are the focus of other Technical Briefs (produced as complements to the *Strategic Framework for WASH Climate Resilient Development*). However, this note does consider the risks posed to sanitation infrastructure by water-related hazards (e.g. flooding) in terms of the potential impact on water supply systems.

Table 1.1 provides a rough classification of the vulnerability of different water supply technologies to climate change. Only those technologies considered "improved" under the World Health Organization (WHO)-UNICEF Joint Monitoring Programme on Water Supply and Sanitation (JMP) are included.

According to this classification, systems such as boreholes that draw water from large, permeable aquifers are the most resilient to all expected climate change impacts. Piped distribution networks may be vulnerable to contamination and will be at increased risk where more frequent flooding occurs, but are potentially resilient to a wide range of climate change impacts where there is sufficient management expertise and finance to maintain and repair systems. In contrast, springs and smaller piped systems may be vulnerable in drying environments without the management expertise and capital associated with larger systems. Systems dependent on shallow groundwater (e.g. dug wells), roof rainwater harvesting and some surface waters are likely to be vulnerable to extended dry periods but also to flooding which increases the risk of pollution.[10]

Table 1.1: Resilience of water technologies to climate change: applicability by 2030

Level of resilience	Technology
Category 1: Potentially resilient to **all** expected climate changes	■ Utility piped water supply ■ Boreholes (tube wells)
Category 2: Potentially resilient to **most** expected climate changes	■ Protected springs ■ Small piped systems
Category 3: Potentially resilient to only a **restricted** number of climate changes	■ Dug wells ■ Rainwater harvesting
Technologies categorised by JMP as "not improved drinking-water sources"	■ Unprotected dug wells ■ Unprotected springs ■ Carts with small tank or drum ■ Surface water (rivers, dams, lakes, ponds) ■ Bottled water

Source: Howard & Bartram (2009)

1.3 Who is this Technical Brief for

This Technical Brief is aimed at WASH sector specialists, technical officers and programme managers in government and partner organisations working at national, sub-national and local levels. The aim is to strengthen their capacity to design and implement a community-centred approach to WSP-Ps that addresses risks to water availability, quality and system functionality posed by climate-related hazards.

The brief provides practical suggestions on how to improve the resilience of community-managed rural water supplies without being too prescriptive. For it to be used widely, efforts should be made to tailor and apply the WSP-P approach to country and local contexts, and to promote its use as part of a wide WASH strategy aimed at improving the sustainability of WASH services.

---

[10] Howard & Bartram, 2009

Box 1: What is a conventional Water Safety Plan

Water safety planning is a preventative risk management approach for ensuring the safety and acceptability of a water supply. It is designed to safeguard drinking-water quality for human health, and provides a comprehensive approach for assessing and managing risks across all links in the water supply chain, from source to consumer.

Water safety plans (WSPs) offer a framework for assessing and identifying typical hazards (e.g. harmful pathogenic microorganisms, chemicals) and related risks, appropriate control measures, critical limits, monitoring requirements and required corrective actions if critical limits are reached. Implementing a WSP can help ensure the safety and acceptability of a drinking-water supply, and can assist users in making prioritised, incremental improvements to address risks over time when resources are limited.

The WSP process for small communities comprises a sequence of six tasks, highlighted in Figure 1.1. The figure illustrates how a conventional WSP can be modified, or broadened, to address the risks to water availability, quality and system functionality posed by climate-related hazards (WSP-Plus, or WSP-P).

Source: Bartram et al. (2009), Greaves & Simmons (2011), WHO (2004; 2012), Rickert et al. (2014)

1.4 Modified water safety plans including environmental and climate change hazard assessment

WSP approaches are increasingly being applied to safeguard drinking-water quality, in part because of their broad applicability and adaptability to different water supply settings at different scales.[11] The aim here is to extend the risk management approach to address the impacts of climate variability and change on water resources, systems and services, recognising that water is predicted to be the main channel through which climate change impacts will be felt by people.

An incremental approach to addressing risks is proposed in light of the fact that it may not be possible to immediately minimise all risks because of, for example, limited financial or human resources.[12] The emphasis is on ensuring the reliability and protection of drinking-water sources under current climate variability as a first step towards adaptation through low-cost – or 'low-regrets' – changes in design or practice.[13] In other words, changes that are likely to generate net social and/or economic benefits under a range of different climate, water and socio-economic futures.[14]

The WSP-P approach adds three sub-tasks to the conventional WSP (Figure 1.1), described further in Section 2. Since risk 'profiles' are likely to vary from place to place, an initial assessment of hazards and vulnerabilities is essential. The three 'additions' to the conventional WSP proposed by WHO[15] are as follows:

- ✓ Task 2b: when describing the community water supply (Task 2a), consideration should be given to catchment size, siting, opportunities for water harvesting, options for using surface water, etc.
- ✓ Task 3b: when identifying and assessing risks and control measures (Task 3a), environmental and climate hazards should also be accounted for.
- ✓ Task 4b: when developing and implementing an incremental improvement plan (Task 4a), interventions to address environmental and climate hazards (e.g. climate resilient investment options, natural resource management, etc.) should be identified and integrated.

Key characteristics of the WSP-P approach are:

- Its '***robustness to uncertainty***': because of the challenges and uncertainties associated with climate modelling, downscaling of rainfall projections and coupling hydrological and climate models,[16] the WSP-P approach is appropriate for a range of rainfall conditions and potential hazards.
- It builds on the identification and assessment of hazards posed to water supply systems by current climate variability and threats that ***represent future climate change impacts***. On this basis, it provides guidance on how communities can use climate sensitivity assessments to define adaptation interventions. It also considers specific risks posed by hazards emanating from WASH infrastructure on water supply, for example through flooding of latrines and the resulting pollution risk.

---

[11] WHO, 2012

[12] WHO, 2012

[13] No-regrets policy/strategy/activity: A policy/strategy/activity that would generate net social and/or economic benefits irrespective of whether or not anthropogenic climate change occurs (Parry et al., 2007). See also the *Strategic Framework for WASH Climate Resilient Development* (GWP and UNICEF, 2014)

[14] Howard & Bartram, 2009

[15] Rickert et al., 2014

[16] Oates et al., 2014; Howard & Bartram, 2009

- Through its comprehensive assessment of hazards and risks, it cuts across the ***disaster risk reduction (DRR), climate change adaptation (CCA) and environmental protection*** domains.
- It proposes ***no and low-regrets adaptation options*** that can be adjusted to reflect the available capacity of communities and local/district/national governments, and identifies the specific and different roles of actors in terms of their implementation (as well as monitoring and evaluation).
- It adopts a ***participatory approach*** in facilitating communities to develop and improve their own WSPs with respect to climate change.

Figure 1.1 below shows the proposed modifications to the WSP approach. It is based on the WHO publication, *Water Safety Plan: A field guide to improving drinking-water safety in small communities* (Rickert et al., 2014) and draws extensively on Calow et al. (Forthcoming, 2015), *Climate Risk Screening for Rural Water Supply.*

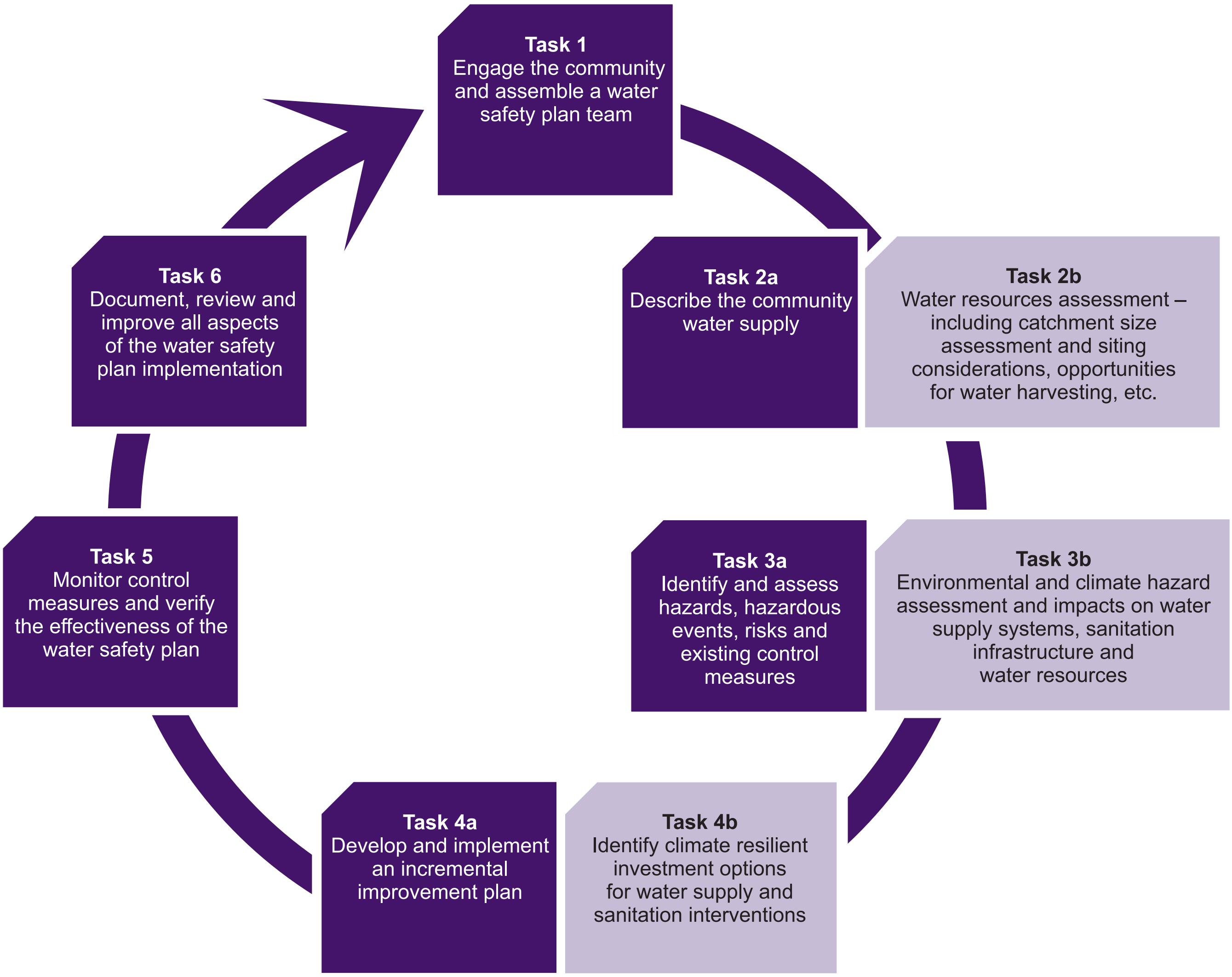

Figure 1.1: 'Modified' water safety plan (WSP-P) approach to include environmental and climate change hazard assessment and identify climate resilient investment options for water supply and sanitation interventions
Source: Rickert et al. (2014) – modified by authors, Day (2009), ICE, Oxfam, WaterAid (2011)

Part 2 – Tasks in detail: A step-by-step approach

This section provides a stepwise process for implementing a WSP-P, following the logic set out in Figure 1.1. Unless otherwise stated, the description below of the WSP-P process largely builds on the WHO publication, *Water Safety Plan: A field guide to improving drinking-water safety in small communities* (Rickert et al., 2014) and draws extensively on Calow et al. (Forthcoming, 2015), *Climate Risk Screening for Rural Water Supply*.

Task 1: Agree the plan, assemble a team and engage the community

As a first step, it is important to obtain the buy-in of those decision-makers overseeing the planning and implementation of a WASH programme (e.g. regional and local governments), and agree who is doing what under the WSP-P. Secondly, a team needs to be assembled to develop, implement and monitor the WSP-P, and to engage communities through recognised community leaders, and/or an existing WASH and/or watershed management committee. Stakeholders with a key role to play include:

- ✓ ***Community members*** with knowledge of the catchment area, including: the location and behaviour (e.g. reliability, quality, seasonality) of water sources used by community members; patterns and levels of water use; management arrangements for system upkeep and access; and broader environmental conditions (land use, degradation, etc.).
- ✓ Alongside local or regional government officials with experience in drinking-water-related issues, ***government officials with experience in natural resource management, DRR and CCA*** should also be invited.
- ✓ ***Technical advisors***, such as: public health officers, economists with experience in conducting cost-benefit analyses (e.g. of adaptation options); hydrologists to provide scientific information and data on climate-related variations and historical trends of water resources; soil conservation officers, forestry officers, and others with knowledge of socio-economic and environmental trends as appropriate.

Community members and water officers from local government should meet within the community to assess current patterns of water availability, access and use as part of the WSP-P process. Specific technical expertise may be difficult to access. Given the flexible nature of the WSP-P approach, however, this should not be an immediate concern. New team members can be added later in the process, or people with specific expertise can be invited at a later stage to help address specific problems.

Tasks 2a and 2b: Describe the community water supply: include water resources

Building on Step 1 of the conventional WSP, the aim here is to build an understanding of the existing water situation within a community. This can usefully begin with a mapping exercise (a good basis for community dialogue) showing the rough location of water points, with a description of source characteristics (quality, reliability/seasonality), the environmental factors that directly or indirectly influence the resilience of services, and the management of sources. The reasoning behind this is that if water services are vulnerable under current weather conditions, the same vulnerabilities will be exacerbated under future ones.

In a situation where a water supply system is not yet established, or where existing services are being appraised, 'normal' WSP activities should be supplemented as follows.

First, Task 2b introduces activities to assess whether geological conditions are likely to provide reliable groundwater with a reasonable yield, and whether the size of the catchment is sufficient to capture the recharge needed to provide a secure supply of water. This is important in those situations where no detailed hydrogeological surveys have been completed, or where no hydrogeological siting techniques are being employed (e.g. geophysical surveys, normally only used to site boreholes). A number of guidance manuals and tools already exist[17] to help identify the most appropriate site for new water supply systems and approaches to hydrogeological surveys. The steps outlined below are most relevant for wells that tap shallow aquifers, but should also be considered alongside other more detailed hydrogeological investigations.

---

[17] *Code of Practice for Cost Effective Boreholes* (Danert et al., 2010), Guidance for *Professionalising Manual Drilling* (http://www.rural-water-supply.net/en/projekts/details/45) and *Developing Groundwater. A guide for rural water supply* (MacDonald et al., 2005)

Geological conditions determine whether groundwater of acceptable quality and yield might be available and how easy or difficult (and costly) it might be to access. Specifically:

- ***Geology determines whether water can be stored in underground formations and the resilience of groundwater resources to changes in baseline climatic conditions.*** The most porous rocks can store large volumes of water and when recharge or discharge occurs the change is small with respect to the existing volume of water. Most likely, at the community level the skills required to assess geology will not exist. Simple geological field guides (e.g. with photographs and local examples) can be developed to aid local water experts to identify rock formations that help in siting water supply systems where the hydrogeology promises most resilient water schemes.
- ***Geological conditions help to determine the most suitable technology.*** Inappropriate technologies can increase the vulnerability of a scheme. Some of the geological considerations to keep in mind when selecting the specific design for a rural water supply scheme are: whether wells should be drilled or dug, lining requirements for hand dug wells, costs related to 'digability' and whether periodic rehabilitation is required, such as the need for dredging silts/sediments. While many water systems have been designed in a rather standardised way (in terms of spring boxes and hand dug well construction), such an analysis would help identify alternative or modified technology choices to improve water supply resilience. A range of suitable guidance is already available to help, for example, determine the most appropriate well construction method or drilling technology.[18]

In addition, the ***siting*** of a water supply is a key consideration. If the catchment area of a source is inadequate in relation to the estimated recharge needed to meet the projected demand for water – across seasons and between wet and dry years – then the source may be unreliable, either now or in the future (see Figure 2.1). This is a particular concern in hilly or mountainous areas where catchments may be small, and where siting is critical.

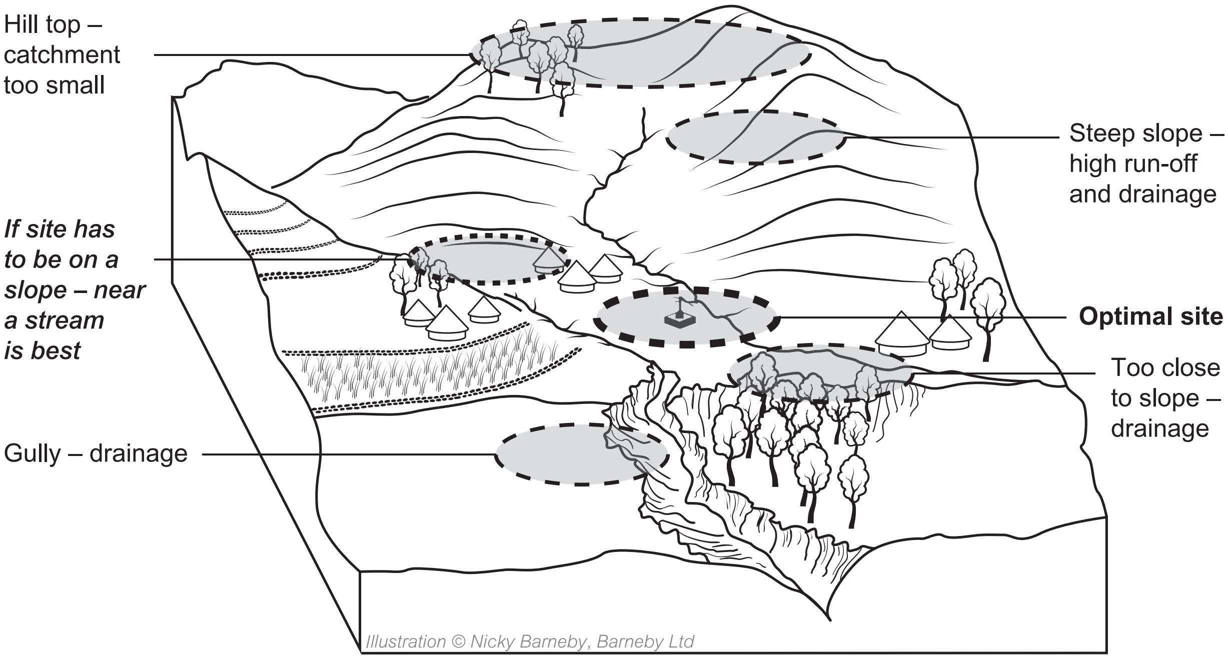

Figure 2.1: Factors to consider when siting a water supply system
Source: Calow et al. (Forthcoming, 2015)

---

[18] See the Rural Water Supply Network (RWSN), (http://www.rural-water-supply.net) or guidance material developed by Practica, UNICEF and EnterpriseWorks/VITA on manual drilling (http://www.unicef.org/wash/index_49090.html)

Estimating the water balance of an aquifer in a catchment is a complex task, requiring data that may not be available. In these situations, the required recharge area can be roughly estimated by comparing the required yield of the source to meet demand and an estimated recharge to groundwater:

- **Water demand** can be estimated based on the number of households to be served and a daily per capita requirement (typically 15 to 20 litres per capita per day for domestic purposes).
- **Recharge** can be estimated using some ‘rule of thumb’ methods, based on evidence from empirical studies in Africa.[19] For areas with rainfall greater than 750 millimetres (mm)/year, a linear relationship between rainfall and recharge can be assumed, with recharge being *approximately* 10% of rainfall.

Not all recharge will end up in shallow aquifers accessible by wells or springs: a proportion may infiltrate to deeper aquifers, may flow laterally to discharge in springs and streams, or may be lost back to the atmosphere through evapotranspiration. Recoverable recharge may therefore range between 10% and 30%. Table 2.1 shows the required catchment area under different assumptions of how many households/people are to be served by a scheme and the theoretical catchment area required to generate enough recharge under different assumptions.

Table 2.1: Estimating the catchment area required to generate sufficient recharge to meet demand

Demand (assuming five persons per household, demand = 20 litres/capita per day)			Catchment area (assuming 1300 mm/year rainfall)		
Households	Daily needs m^3	Annual needs m^3	Recharge 10% of rainfall[20] m^2	Recharge 3% of rainfall m^2	Recharge 1% of rainfall m^2
20	2	730	5,615	18,718	56,154
50	5	1,825	14,038	46,795	140,385
70	7	2,555	19,653	65,513	196,539

Source: Calow et al. (Forthcoming, 2015)

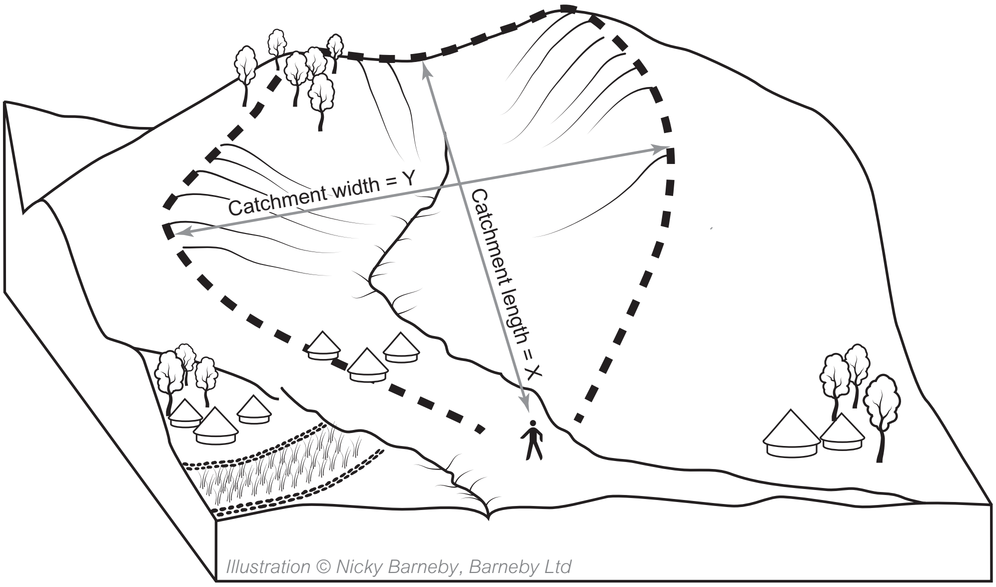

Figure 2.2: Estimating the catchment area (recharge area) for a water supply
Source: Calow et al. (Forthcoming, 2015)

---

[19] Bonsor & MacDonald, 2010

[20] Calculated as demand (in cubic metres [m^3])/recharge (in m^3) i.e. 730/0.13 = 5,615 square metres [m^2] (75 m x 75 m)

Tasks 3a and 3b: Identify and assess hazards, hazardous events, risks and existing control measures: include environmental and climate hazard assessment

Under Task 3 of the WSP-P, it is suggested that a process of hazard identification is conducted along the entire drinking-water supply chain to identify actual and potential risks and their causes. In other words, the team needs to ask: *"What can go wrong? How, when, where and why?"*

In addition to considering the obvious hazards associated with water supply (e.g. biological, chemical, physical or radiological contamination captured under a conventional WSP), attention should be paid to environmental and climate-induced hazards. Reasons include:

- The growing recognition of the **health effects** associated with contamination of water bodies and water sources after extreme weather events,[21] often as a result of damage to sanitation infrastructure caused, for example, by the flooding of latrines.
- Sources and the resources they depend on can be affected by ***direct hazards***, such as expanding gullies, changing patterns, intensity or frequency of floods and landslides in the immediate vicinity of the system, and ***indirect hazards*** such as catchment degradation (e.g. deforestation, overgrazing, soil erosion, etc.) which can affect runoff and infiltration, in turn affecting the local resource base (see Figure 2.3).

With these considerations in mind, Task 3b of the WSP-P should include:

1. ***An assessment of current rainfall extremes*** (amount and seasonal distribution) and implications for WASH systems.
2. ***An assessment of environmental and climate-induced hazards*** such as landslides, flooding, more pronounced seasonality, drought or expanding gullies – and their impacts on WASH systems.
3. ***An assessment of current degradation processes in the catchment area*** of the water system that might, over time, undermine its sustainability and resilience.
4. ***An elaboration of a catchment protection plan*** addressing key degradation processes.

This will help provide the information needed to determine whether a potential site, selected on the basis of criteria such as geological conditions, catchment size and user access, is the best possible

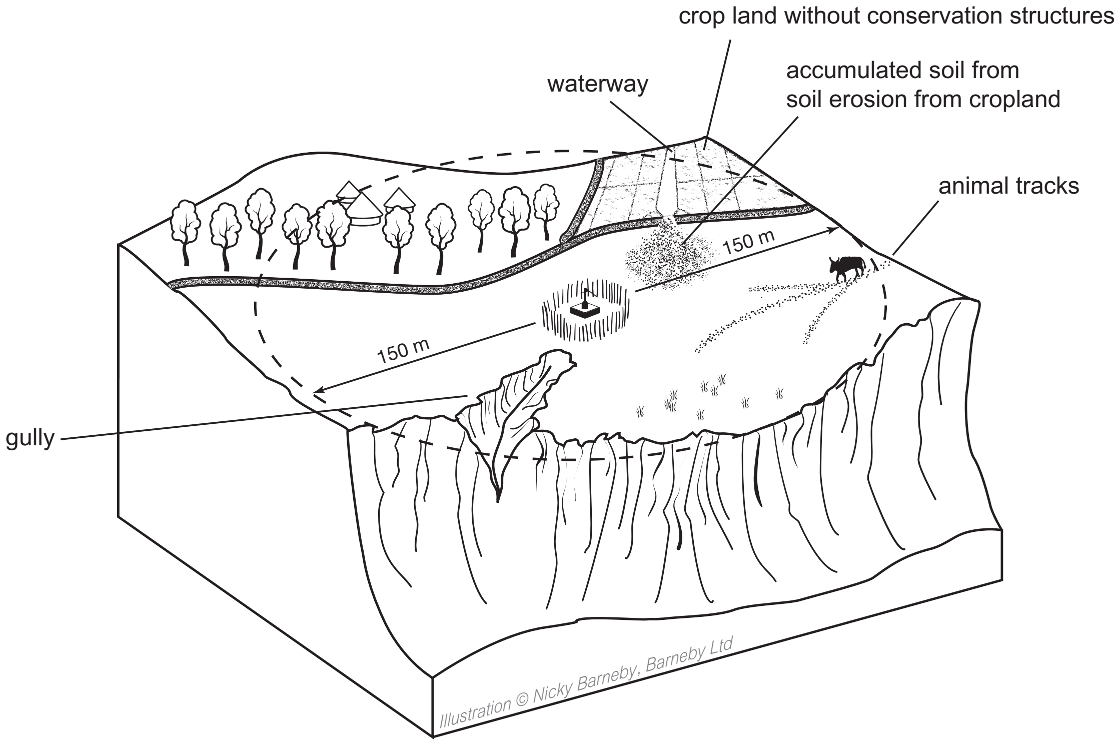

Figure 2.3: Environmental hazards in the vicinity of a water supply system (or of sanitation infrastructure such as latrines) may lead to direct damage to the infrastructure (e.g. through flooding or landslides). Degradation processes in the wider catchment area may lead to increased runoff and reduced groundwater recharge
Source: Calow et al. (Forthcoming, 2015)

---

[21] Sinisi & Aertgeerts, 2010

option from an environmental and climate (including extreme events) point of view. If major hazards have been identified that might threaten the water scheme (see Figure 2.3) that cannot be addressed, the team may want to consider alternative sites. The same holds for sanitation infrastructure such as latrines – are they threatened by flooding, for example? Otherwise, if the threat can be addressed, the team should action appropriate protection measures, ideally detailed in a catchment protection plan (see Task 4a). These may include gully rehabilitation, runoff management to avoid flooding, and afforestation to prevent further landslides (Table 2.2).

Indirect hazards to water supply systems can also stem from pollution originating from areas used by communities for open defecation or from sanitation infrastructure that, if damaged, can pose a serious pollution risk. Measures to consider include: initiating community-led total sanitation (CLTS) approaches in order to minimise open defecation, relocating sanitation infrastructure away from flood-prone areas or adapting latrine design (for further details see for example: On-site sanitation in areas with a high groundwater table (Parry-Jones, 1999).

In situations where there is insufficient information about the magnitude of future hazards, ***ex ante sensitivity analyses***[22] could be used to estimate whether current hazards are likely to remain the same, intensify or reduce in frequency and intensity in the future as a consequence of climate change. For example, flooding events may become more or less frequent and/or more or less extreme, drought may become more or less frequent/dry spells longer or shorter, etc. The team should consider possible outcomes on a specific water supply scheme and discuss the most appropriate adaptation options.

In addition to identifying environmental and climate-induced hazards, the most relevant of which are listed in Table 2.2, it is also important to understand what measures to enhance the resilience of water supply systems are already in place, or the existing activities and processes that could be used to prevent, eliminate or significantly reduce the occurrence of a potential hazard. These could include, for example, assessing what activities have already been initiated to protect water sources, and how they could be strengthened. Identifying activities initiated as part of a disaster risk management or natural resource management plan could highlight initiatives that already have an impact on water supply systems, but that could be further strengthened to increase the resilience of water supply systems. This assessment should also include a review of the resources that are available to the community and its information needs.

Activities under Task 3b should be based on ***community knowledge***, including people's experience of heavy runoff or floods and the recurrence of long dry spells or droughts, and impacts on water quality, availability/reliability and the functionality of systems.

Tasks 4a and 4b: Develop and implement an incremental improvement plan: include consideration of climate resilient adaptation options for water supply interventions

Step 4 sets out the measures that can be considered to address the risks identified in Task 3. For example, catchment management interventions aimed at protecting water resources and infrastructure could be carried out for existing water points, and changes to the design and construction of new water supply systems and latrines could be introduced.[23] The incremental nature of the WSP-P allows for the identification of priority measures, and less important ones that can be implemented at a later date. This helps ensure that limited funds, from within and outside the community, are used effectively.

Tasks 4a and 4b can be conducted in two phases:

1. First of all, the team needs to ***review the hazards identified in tasks 3a and 3b*** and, for each of these, ***list possible measures*** that could be put in place to address them (see Table 2.2).
2. Based on the measures identified, an ***improvement plan*** should be developed that clearly defines which measures can be implemented in the short, medium and long term with available resources.

In conducting these tasks, three additional considerations should be: the criteria for selecting the measures for the improvement plan; the importance of focusing on the larger catchment area of a water supply system; and the need to coordinate across traditional silos.

i. **Identifying most appropriate adaptation measures:** In selecting the most appropriate no/low-regret measures to increase the resilience of water supply systems, the community should also consider the following criteria:[24]
   - ✓ ***Practicality of the option(s):*** is it achievable given the available technical and financial

---

[22] The simplest form of sensitivity analysis is to vary one value in a model by a given amount and examine the impact this change has on the model's result

[23] Oates et al., 2014

[24] Adapted from: Venton, 2010

resources, organisational capacity and within the given timeframe?

- ✓ ***Benefits:*** how many vulnerable people are likely to benefit from the mitigation measure, taking account of any unintended negative consequences?
- ✓ ***Cost-effectiveness:*** is funding available? If possible, a cost-benefit analysis (CBA)[25] should be carried out. Otherwise, an assessment of available financial means and cost implications of the adaptation measures can be carried out by the community.

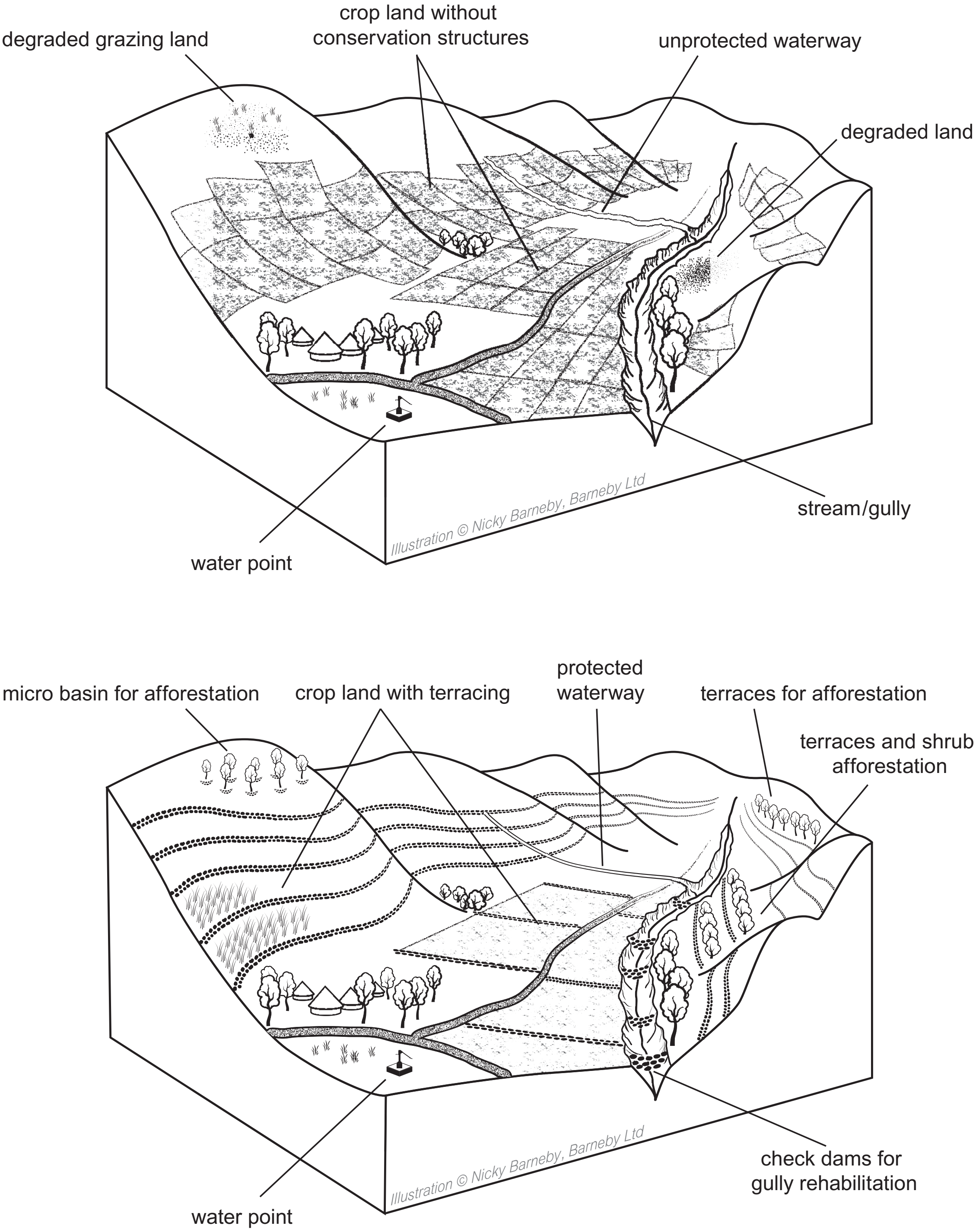

Figure 2.4: Natural resource degradation features that might undermine the resilience of a water supply (top) and possible mitigation measures as laid out in a catchment protection plan (bottom)
Source: Calow et al. (Forthcoming, 2015)

---

[25] CBA is an economic tool used to compare the benefits against the costs of a given project or activity, also taking account of any changes in human wellbeing arising from a given activity, besides its financial impacts. It can be used before an investment is made to choose between options ('forward-looking'), or after an activity has already been undertaken to demonstrate the economic value of the activity ('backward-looking'). See Venton, 2010

This should take into account annual operating and maintenance costs, as well as the initial capital investment.

- ✓ ***Environmental sustainability:*** in the short and long term, taking account of expected weather and climate variability, will the measure still be viable in 10-20 years?
- ✓ ***Political feasibility:*** are the proposed mitigation measures compatible with the development objectives and policies of local/ national governments, and are they culturally and socially acceptable at the local level?
- ✓ ***Likelihood of success:*** are the adaptation measures likely to be successful regardless of climate change, e.g. are they no-regret/ low-regret measures?

Some risk adaptive or preventative technologies and management approaches are illustrated in Figure 2.4 and described in more detail in Table 2.2. Each has advantages and disadvantages that make it more or less suitable for implementation at the community level. Fundamentally, it will be the role of teams to select the most appropriate option(s) depending on the type of scheme, the delivery model and local capacity. It is important to note that each option will have implications in terms of costs, training needs and the additional information required.

ii. Catchment management: Besides looking at the water supply system and its specific vulnerability to climate change (Table 2.2), it is important to ***focus on the larger catchment area of a water supply system***. In Task 3b, major environmental and climate-induced hazards are identified. Often, natural resource management measures are beyond the technical expertise of WASH technicians and local communities; therefore, collaboration with experts from government authorities and external agencies specialising in natural resource management, including disaster risk management, is important.

iii. Coordination: In many countries there are government programmes, often supported by donors, aimed at building the resilience of rural livelihoods to climate change, with a focus on natural resource management. However, such programmes rarely coordinate with WASH activities, with the result that important synergies are lost, for example, to implement catchment management prior to a WASH programme to ensure sources and resources are protected. Every effort should be made to work across traditional silos.

Table 2.2: Possible interventions to build climate resilience
Sources: Calow et al. (2011); Elliot et al. (2011) – compiled by authors

Hazard	Impact on water supply systems		Adaptation options	Implication for communities (+ = positive, – = negative)
	Direct	Indirect		
Drought	Reduced water availability	Population movements to other areas, posing further stress on remaining water sources and use of unsafe sources	**Collection and storage of surface water runoff:** ■ Below ground tanks (i.e. cisterns) and excavations into which rainwater is directed from the ground surface ■ Small reservoirs with earthen bunds or embankments to contain runoff or river flows ■ Managed aquifer recharge: capturing and recharging excess runoff in the vicinity of a well or borehole	+ Stored runoff can be used for non-potable uses (e.g. garden irrigation), reducing pressure on higher quality (domestic) sources. In some regions stored water can be used for drinking in the dry season with adequate treatment + Storage provides a good alternative when water availability is insufficient, but technical, environmental, social or legal concerns may preclude development of reservoirs if they are too large + or – Potentially high costs depending on the scale of the project and location (availability of donors may help, but issues of sustainability when project completed) – Capturing runoff can affect downstream communities, reducing their water availability + or – Directing excess runoff down, for example, abandoned wells to recharge aquifers can fast-track contamination

Continued on next page

Hazard	**Impact on water supply systems**		**Adaptation options**	**Implication for communities (+ = positive, – = negative)**
	Direct	**Indirect**		
Drought (continued)	Reduced water availability (continued)	Population movements to other areas, posing further stress on remaining water sources and use of unsafe sources (continued)	**Rainwater collection and storage** – e.g. via rainwater harvesting from roofs (RWH) to collect water for potable and other uses. RWH options in a given setting depend on the quality, cost and sustainability of other residential water supplies, precipitation patterns, household income, etc. For more about the basic features of rooftop RWH systems see: Elliot et al., 2011	+ Widespread practice, relatively low-tech and low-cost: stored rainwater is a convenient, inexpensive water supply close to home – which can decrease the time spent fetching water or queuing at water points + Low operation and maintenance requirements: mostly simple cleaning and basic repairs + RWH can reduce exposure to waterborne pathogens by providing improved potable water quality and water for other household purposes, including hygiene, bathing and washing + Generally requires little training or capacity building, only local supply chains for storage containers and system components should be in place – Where not normally practised, local manufacture and supply of materials may be weak or non-existent – The costs of high quality storage containers may still be a major investment for poor rural households. Group investments can help – Future changes in rainfall patterns need to be considered when deciding the size of storage
			New or rehabilitated groundwater sources: ■ Drilling new wells or boreholes/ deepening existing ones ■ Repairing damaged wells/ boreholes ■ Relief boreholes with use restricted to emergencies	+ Where information is good, sources can be developed based on available maps and information on yield/performance from nearby boreholes + Well-constructed deep boreholes typically yield water of good microbial quality (but deep aquifers can be contaminated with arsenic and fluoride, so the water is not suitable for drinking purposes) – Although wells can be dug by various methods, deep boreholes require drilling using an external power source at high cost – Requirement for more detailed knowledge of population distribution, groundwater resources and water point location/status – which may not be available to communities – Dependence on access to national and international markets for drilling equipment, spare parts and consumables – hence need for donor and/or government support

Continued on next page

Hazard	Impact on water supply systems		Adaptation options	Implication for communities (+ = positive, – = negative)
	Direct	Indirect		
Flooding	Damage to infrastructure (e.g. collapse of unlined wells when soil becomes saturated, and physical damage to wellhead)		**Improving resilience of protected wells to flooding** (including boreholes and hand dug wells) ■ Adaptation measures to the wellhead/spring box ■ Switching from unprotected to protected wells with hand pumps ■ Casing wells with watertight material ■ Raising the wellhead ■ Placing wellhead on mound to allow floodwater to drain away ■ Flood protection (e.g. levees, drainage ditches, artificial waterways, soil and water conservation on adjacent land to enhance infiltration and reduce runoff, etc.) ■ Area closure/re-vegetation/ afforestation ■ Household water treatment and hygiene behavioural training ■ Prepositioning of tool kits, test kits and disinfection kits **Post-construction support (PCS) for community-managed water supplies, e.g.** ■ Technical training for water system operator ■ Technical and engineering support, including provision of technical manuals ■ Financial and accounting assistance (e.g. in setting tariffs) ■ Help settling disputes ■ Help with maintenance, repairs and finding spare parts ■ Help finding external funding for O&M, expansion or repairs ■ Household visits to residents to discuss water system use, etc.	+ Only basic requirements to implement this technological option (which should be present in WSP team) including: basic knowledge of water supply technology and experience drilling a given type of well/basic concrete construction skills + Retro-fitting for flooding, including raising the wellhead on a plinth, can generally be accomplished with basic construction supplies at or close to the ground surface – Construction of new wells can be very expensive
		Inaccessibility of water sources	■ Flood protection (such as levees, drainage ditches, artificial waterways, etc.) ■ Raising wellhead	
	Inundation of wells		■ As above	

Continued on next page

Hazard	Impact on water supply systems		Adaptation options	Implication for communities (+ = positive, – = negative)
	Direct	Indirect		
Flooding (continued)		Pollution of water sources (and consequent health effects, e.g. increase in waterborne diseases)	**Household water treatment and safe storage (HWTS)** A list of HWTS technologies is provided by Elliot et al., 2011, p 25 Including treatment of drinking water by heating	+ Relatively cheap and diffused HWTS technologies (new ones continuing to emerge) and easy to operate and maintain, hence accessible also at household level + and – Some technologies have few if any capital costs (e.g. chemical disinfectants), but must be purchased periodically; others (e.g. biosand filters) have relatively large up-front costs with little or no ongoing costs + and – Appropriate for crisis times (e.g. in refugee camps following natural disasters) also because of donor subsidies, but otherwise modest uptake and sustained use+ and – Boiling water is highly effective at eliminating all classes of pathogens but has numerous disadvantages in terms of the time to gather fuel, risk of deforestation in areas with limited alternative fuels, sometimes prohibitive costs, and degradation of indoor air quality leading to increased health hazards – Some HWTS technologies (e.g. chemical disinfectants) are consumable and need to be replaced frequently. Also, there might be problems of regular supply to rural areas, challenges in applying the appropriate dosage or rejection of use. Therefore, regular water quality testing is required – Potentially high costs associated with training and educating users
	Flooding of areas used for open defecation	Pollution of water sources (and consequent health effects, e.g. increase in waterborne diseases)	Initiation of community-led total sanitation (CLTS) approaches	+ Relatively cheap + Potential to empower and mobilise community members towards collective action beyond sanitation and hygiene
	Flooding of latrines	Consequent health effects, e.g. increase in waterborne diseases	**Adjustments to the location and design of latrines:** ■ Ensuring minimum distance between latrines and water sources ■ Relocation of latrines away from flood-prone and low-lying areas ■ Raising latrines and ensuring minimum distance between pit and water table is maintained ■ Short life or disposable pits ■ Composting latrines ■ Cess pits and sealed septic tanks, raising of toilet pan above flood level, non-return valves to prevent back-flows ■ Regular emptying	

Continued on next page

Hazard	Impact on water supply systems		Adaptation options	Implication for communities (+ = positive, – = negative)
	Direct	Indirect		
Heatwaves		Damage to infrastructure	**Post-construction support (PCS) for community-managed water supplies (see above)**	
		Water quality problems, e.g. due to algal blooms (and consequent health effects, e.g. increase in waterborne diseases)	**Household water treatment and safe storage (HWTS)**	
Storm damage	Damage to infrastructure		**Post-construction support (PCS) for community-managed water supplies (see above)**	
		Landslides around water sources	■ Retention walls ■ Afforestation of a large area around landslide-prone slopes ■ Fencing to reduce further destruction of vegetation cover ■ Controlled grazing of livestock	– Communities may oppose fencing off areas as this might interfere with land use and livestock management practices
	Gully erosion, e.g. due to intense rainfall	Sedimentation and turbidity	**Control gully development/gully protection and rehabilitation** ■ Improvement of gully catchment to reduce and regulate runoff volume and peak amounts, including land management practices, soil and water conservation, afforestation, controlled grazing, etc. ■ Diversion of runoff water upstream of the gully area, including cut-off drains, retention and infiltration ditches, etc. ■ Stabilisation of gullies by structural and vegetative measures, including gully head control, gully reshaping, check dams and vegetative measures inside gully to encourage deposition of sediments ■ Where possible, avoid building wells in gullies – or cap unused bores and ensure current wells are appropriately sealed from surface runoff	– Need to be maintained regularly (structures should be observed for damage especially during rainy season and after heavy storms): often not enough capacity to do so at community level. Therefore, coordination with and involvement of local authorities such as soil conservation officers, forest officers, etc. needs to be ensured

Continued on next page

Hazard	Impact on water supply systems		Adaptation options	Implication for communities (+ = positive, – = negative)
	Direct	Indirect		
Sea-level rise	**Saline intrusion** (affecting groundwater and coastal surface water especially during dry season in regions with high rainfall variability)[26]	Further decreasing freshwater availability in coastal areas	**Household water treatment and safe storage (HWTS)** **Other measures** that can be considered to mitigate risks linked to salinisation: ■ Maintain critical dilution flows in rivers and streams ■ Minimise high saline loads from specific sources entering rivers and streams (for example irrigation drainage or wetland discharge) ■ Maintain or improve landscape vegetation to reduce shallow groundwater salinisation ■ Control abstraction rates to prevent saline ingress ■ Managed aquifer recharge to create fresh lenses of water in aquifers with high concentration of salts (see for example: http://www.bebuffered.com/downloads/3R_managing_the_water_buffer_2010.pdf) ■ Deepening tube wells	
Natural resource degradation **Catchment degradation**		Decreasing soil depth and vegetation cover reduces infiltration and increases runoff which can lead to falling groundwater tables	A broad range of natural resource management and soil and water conservation interventions exist: ■ Soil erosion on crop land: land management practices (e.g. ploughing along contours, increasing organic matter content of the soil, etc.), soil and stone bunds, terraces, artificial water ways, cut-off drains above crop land ■ Vegetation degradation: controlled grazing of livestock, reforestation ■ Afforestation ■ Runoff management ■ Gully rehabilitation ■ Water harvesting	+ Contribute to wider improvements of natural resources – Require coordination with other government line departments

---

[26] Elliot et al., 2011, p. 4

Task 5: Monitor mitigation measures and verify the effectiveness of the modified water safety plan

The purpose of Task 5 is to confirm that the community water supply is operating as expected and that the WSP-P is protecting drinking-water safety both in terms of quality and quantity.[27]

It is important that the monitoring programme includes specific indicators and objectives to assess how the control measures implemented through the WSP-P are performing in terms of preventing or responding to the hazards identified, and to monitor progress against targets or objectives. Not only should environmental and climate considerations be part of the normal monitoring process, but they should also serve to trigger increased vigilance every time a sudden change in the local environment (e.g. due to heavy rainfall) occurs. Therefore, the team must continually review the needs of the monitoring programme in light of newly identified risks that may affect drinking-water supplies.

As many of the risks associated with environmental and climate-induced hazards will be also picked up by the 'normal' monitoring process under the WSP-P, such as damage to a wellhead after a major flooding event, the focus of the monitoring here should be on:

- ✓ Regular inspection of the well for siltation
- ✓ Regular monitoring of the water table in the well
- ✓ Regular monitoring of the functionality of investments initiated to address environmental and climate-induced hazards in the catchment area such as check dams and gully rehabilitation, cut-off drains and water ways, afforestation, soil and water conservation structures on crop land, etc.

Monitoring activities should include community members, but should also be carried out in close collaboration with relevant government and non-government agencies, involving both those responsible for WASH and those for natural resource management. This will most likely require setting up a dedicated committee comprising representatives from different government ministries and community members with the required organisational structures and institutional arrangements.

Task 6: Document, review and improve all aspects of water safety plan implementation

The purpose of Task 6 is to document the status and the level of operation and management of the water supply system, to ensure that the WSP-P approach is embedded in operations and that it remains up to date and effective. The development of the WSP-P is likely to have yielded a lot of information, for example on the origin of the system, its design and construction, or ownership details of the land on which a reservoir or a hand pump was built, or of the water resource situation in a locality. If the WSP-P has been developed along the lines set out in this brief on how to integrate climate resilience, it will also include relevant details on the vulnerability of the water system to climate variability and change, as well as to changes such as population growth or modified regulations for water and land management.

From here, it is important to develop a set of instructions on how to operate the system. These might be called management procedures or standard operating procedures and collected in manuals. Incident/emergency management procedures should be included to help the community respond to unforeseen events. Therefore, manuals should include provisions for a continuum of operations, from normal events to incidents, emergencies and, finally, disasters.[28] Given the variability of climate, environmental and other conditions, and the great uncertainties associated with future trends, it is important that such manuals are not 'set in stone', but regularly revised and updated. Periodically, the team should meet to review the WSP-P and learn from experience and new procedures. Periodic reviews are particularly important for small community-managed water supplies where capacity is limited, and where the objective is to make incremental improvements over time towards greater resilience.

---

[27] For more information on how to establish and conduct monitoring programmes, see: WHO, 2012, and Greaves & Simmons, 2011

[28] See, for example: Sinisi & Aertgeerts, 2010

References

Bartram, J., Corrales, L., Davison, A., Deere, D., Drury, D., Gordon, B., Howard, G., Rinehold, A. and Stevens, M. (2009) *Water Safety Plan Manual: Step-By-Step Risk Management for Drinking-Water Suppliers*. World Health Organization, Geneva.

Bonsor, H. and MacDonald A. (2010) *Groundwater and Climate Change in Africa: Review of Recharge Studies*. British Geological Survey Internal Report, IR/10/075. BGS, Keyworth.

Calow, R., Bonsor, H., Jones, L., O'Meally, S., MacDonald, A. and Kaur, N. (2011) *Climate Change, Water Resources and WASH. A Scoping Study.* Working Paper 337. Overseas Development Institute, London.

Calow, R., Kebede, S., McKenzie, A. and Ludi, E. (Forthcoming, 2015) *Climate Risk Screening for Rural Water Supply*. Overseas Development Institute, London.

Danert, K., Armstrong, T., Adekile, D., Duffau, B., Ouedraogo, I. and Kwei, C. (2010) *Code of Practice for Cost Effective Boreholes*. Rural Water Supply Network, St Gallen.

Day, S. (2009) Community-Based Water Resources Management. *Waterlines* 28(1), pp. 47–62. doi: 10.3362/1756-3488.2009.005.

Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. (2011) *Technologies for Climate Change Adaptation – The Water Sector*. (T. De Lopez, Ed.). UNEP, Roskilde.

Greaves, F. and Simmons, C. (2011) *Water Safety Plans for Communities: Guidance for Adoption of Water Safety Plans at Community Level*. Tearfund, Teddington.

GWP and UNICEF (2014) *Strategic Framework for WASH Climate Resilient Development*.

Howard, G. and Bartram, J. (2009) *Summary and Policy Implications Vision 2030: The Resilience of Water Supply and Sanitation in the Face of Climate Change*. World Health Organization, Geneva.

ICE (The Institution of Civil Engineers), Oxfam GB, WaterAid (2011) *Managing Water Locally. An Essential Dimension of Community Water Development*. ICE, Oxfam and WaterAid, London and Oxford.

IPCC (2014) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea and L.L. White (eds.)]. Cambridge University Press, Cambridge and New York.

MacDonald, A., Davies, J., Calow, R. and Chilton, J. (2005) *Developing Groundwater. A Guide for Rural Water Supply.* ITDG Publishing, Bourton-on-Dunsmore.

Oates, N., Ross, I., Calow, R., Carter, R. and Doczi, J. (2014) *Adaptation to Climate Change in Water, Sanitation and Hygiene: Assessing Risks and Appraising Options in Africa*. Overseas Development Institute, London.

Parry-Jones, S. (1999) *On-site Sanitation in Areas with a High Groundwater Table.* (http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/lcsahgt.htm)

Parry, M., Canziani, O., Palutikof, J., Linden, P. van der and Hanson, C. (2007) *Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability*. Cambridge University Press, Cambridge.

Rickert, B., Schmoll, O., Rinehold, A. and Barrenberg, E. (2014) *Water Safety Plan: A Field Guide to Improving Drinking-Water Safety in Small Communities*. World Health Organization, Copenhagen.

Sinisi, L. and Aertgeerts, R. (2010) *Guidance on Water Supply and Sanitation In Extreme Weather Events*. World Health Organization, Copenhagen.

UNICEF, Skat Foundation (n.d.) *Professionalising Manual Drilling.* (http://www.rural-water-supply.net/en/projekts/details/45)

Venton, P. (2010) *How to Integrate Climate Change Adaptation into National-Level Policy and Planning in the Water Sector: A Practical Guide for Developing Country Governments.* Tearfund, Teddington.

WHO (2004) *Guidelines for Drinking-Water Quality.* 3rd edition. World Health Organization, Geneva.

WHO (2005) *Water Safety Plans*. World Health Organization, Geneva.

WHO (2012) *Water Safety Planning for Small Community Water Supplies: Step-By-Step Risk Management Guidance for Drinking-Water Supplies in Small Communities.* World Health Organization, Geneva.

Acknowledgements

Preparation of the *Strategic Framework for WASH Climate Resilient Development* was led by a joint Global Water Partnership-United Nations Children's Fund (GWP-UNICEF) team including Cecilia Scharp and Jose Gesti Canuto and Emily Bamford UNICEF; and Jacques Rey, Alex Simalabwi and Susanne Skyllerstedt, Armand Houanye, and Sara Oppenheimer, Global Water Partnership Organisation (GWPO). The Framework documents were prepared by HR Wallingford in collaboration with the Overseas Development Institute (ODI) and Peter Bury on behalf of GWP and UNICEF. The lead authors for the Technical Brief on *Local participatory water supply and climate change risk assessment: Modified water safety plans*, which supports implementation of the Framework, were Eva Ludi, Beatrice Mosello and Roger Calow (ODI).

We are grateful for the valuable input from regional and country-based experts, and practitioners from UNICEF, GWP, WaterAid and others who took part in our consultation exercises and also reviewed drafts of the Framework documents. These included: Arinita Maskey Shrestha and Overtoun Mgemezulu, UNICEF Nepal; Kelly Ann Naylor and Anne-Cecile Vialle, UNICEF Democratic Republic of the Congo (DRC); Peter Harvey, UNICEF Eastern and Southern Africa Regional Office (ESARO) Nairobi; Chander Badloe, Erik Kjaergaard, Maya Igarashi-Wood and Guy Mbayo Kakumbi, UNICEF East Asia & Pacific Regional Office (EAPRO); Pierre Fourcassie, UNICEF Regional Office for the Middle East & North Africa; Hendrik van Norden, UNICEF Regional Office for South Asia (ROSA); Michael Emerson Gnilo and Simone Klawitter, UNICEF Philippines; Alex Heikens, Climate Change Advisor, UNICEF Division of Policy; Antony Spalton, UNICEF Programme Division; Maika Mueller and Ralph Philip, GWPO; Priyanka Dissanayake, GWP South Asia; Andrew Takawira, GWP Water, Climate and Development Programme (WACDEP) Coordination Unit; and Vincent Casey, WaterAid West Africa. We are also indebted to the panel of experts who have reviewed and commented on our draft reports. These were: Alan Hall, GWP Senior Advisor; Merylyn Hedger, GWP Senior Advisor; Michele Messina, independent; Belynda Petrie, OneWorld; and Melvin Woodhouse, independent. Thanks also to Monika Ericson, GWPO, for coordinating the production of the publications.

UNICEF
3 United Nations Plaza
New York, NY
United States
www.unicef.org

Global Water Partnership
Global Secretariat
PO Box 24177, SE-104 51 Stockholm
Sweden
www.gwp.org, www.gwptoolbox.org