GLOBAL WASH CLUSTER

CAPACITY BUILDING FOR HUMANITARIAN RESPONSE

DISASTER RISK REDUCTION AND WATER, SANITATION AND HYGIENE...

COMPREHENSIVE GUIDANCE

A GUIDELINE FOR FIELD PRACTITIONERS PLANNING AND IMPLEMENTING WASH INTERVENTIONS

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ACRONYMS

CC	Climate Change
CCA	Climate Change Adaptation
DRA	Disaster Risk Assessment
DRR	Disaster Risk Reduction
EPP	Emergency Preparedness Plan
HP	Hygiene Promotion
KAP	Knowledge, Attitude and Practice
MDG	Millennium Development Goals
NGO	Non-Governmental Organization
PAR Model	Pressure and Release Model
PRA	Participatory Rural Appraisal
USD	United States Dollar
VDC	Village Development Committee
WASH	Water, Sanitation and Hygiene
WSP	Water Safety Plan

1 INTRODUCTION

In 2008 the WASH Cluster commissioned a study to explore the links between Water, Sanitation and Hygiene (WASH) and Disaster Risk Reduction (DRR) in emergency response and early recovery in WASH cluster agencies. The project was set up in two parts; the first part was a study on the integration of DRR in WASH programming in emergency response and early recovery in WASH cluster agencies. The second part was to create a guideline with tools to assist agencies in mainstreaming DRR in WASH, building on the results of the study. The study identified several issues:

- Disaster Risk Reduction measures related to WASH are already being put in practice (although this is not necessarily recognised by field practitioners).
- Field practitioners and staff at headquarters would like to see clear guidance on good practice of DRR with regard to WASH services and WASH programming. DRR thus needs to be de-mystified.
- There is some limited guidance on risk reduction in WASH services in stable situations; there are no specific guidelines and tools for the integration of risk reduction measures in WASH in the emergency response and early recovery phases.
- The guidance available that deals with risk reduction in respect to WASH systems are mostly focussed on water supply systems. Measures related to other WASH systems (e.g. sanitation, vector control) are less developed.

The document in front of the reader is the guideline, including the tools, which will fill these gaps. It provides a comprehensive overview of integration of DRR in WASH, and is a companion to the summary document ' Disaster Risk Reduction and WASH – Essential Guidance'.

The study also revealed that agencies considered 'preparedness' (before a disaster event) as the most effective risk reduction approach. This observation is correct, and should include mitigation in the development phase to complete the circle. To accommodate these key elements within Disaster Risk Reduction, the scope of the guideline was extended to allow for mitigation and preparedness measures in the development phase to be linked with the emergency response and recovery phases.

1.1 SCOPE OF THE GUIDELINE

This guideline will focus on the links between WASH and DRR in emergency response and early recovery. As said earlier, planning for disasters in the development phase through mitigation and preparedness is essential to reducing the risk to WASH systems. Therefore the guideline will also explore DRR measures that can be taken in the development phase.

In this guideline the following WASH components are covered:

- Water supply
- Excreta disposal
- Hygiene practice
- Vector control
- Solid waste management
- Drainage of wastewater and stormwater

The principles and tools presented in this guideline are applicable both to rural and urban contexts as well as both small and larger systems (e.g. handpumps in a village versus an urban water supply system).

The focus will be on systems that supply services to households, villages and neighbourhoods (i.e. systems that practitioners of WASH cluster agencies will normally deal with). While many of the principles covered here could also be applied to services for industry or large-scale irrigation schemes, the guideline will not look specifically into these systems.

The guideline will focus on hazard events that are called 'natural hazards'. These hazards are presented in **Figure 1.**

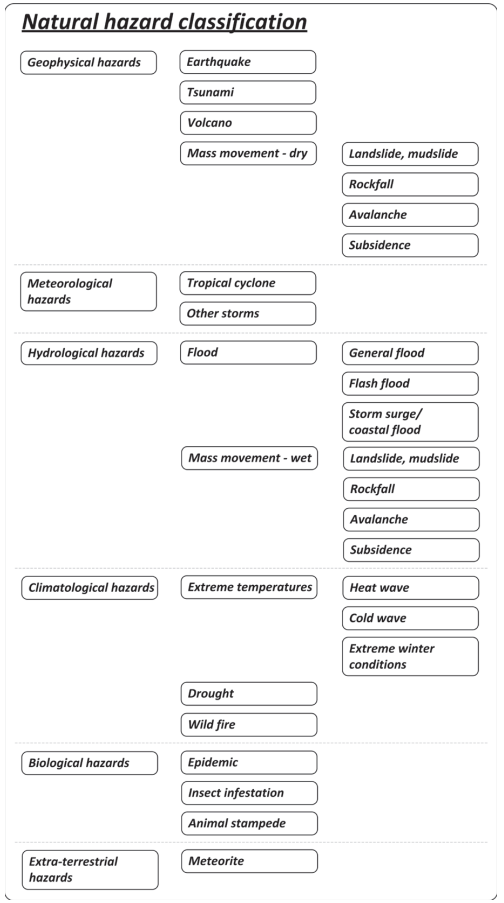


Figure 1: Classification of natural hazards [1]

The guideline will not deal with technological hazards (e.g. transportation and industrial hazards) and international, civil and political hazards (e.g. wars, complex humanitarian emergencies).

1 Insect infestation, animal stampede and meteorite impact will not be covered in the guideline

1.2 TARGET AUDIENCE

The guideline is written for field practitioners who plan, coordinate and implement WASH interventions in the emergency response, recovery and development phases.

It is assumed that the readers have a sound understanding of WASH principles and standards in emergency response and recovery. Readers should be familiar with project planning methods and tools (e.g. use of the logical framework). It is also assumed that methodologies used in the planning of WASH, like PRA (Participatory Rural Appraisal) and its techniques are familiar. However, it is not necessary to have a firm understanding of DRR as this document will cover the basic concepts.

1.3 STRUCTURE OF THE DOCUMENT

The document is meant to provide quick access to information. Chapters 2 and 3 provide a background to DRR and its integration into WASH programmes. The annexes present overview tables for rapid access to background information and tools.

- Chapter 1 **Introduction:** sketches the general background, scope of the document, target audience and structure of the guideline.
- Chapter 2 **Disasters and Disaster Risk Reduction:** concepts and context: discusses disasters and past and future disaster trends / projections. It introduces the concepts of disaster risk and disaster risk reduction.
- Chapter 3 **DRR and WASH services:** presents the integration of DRR into WASH interventions. It takes a general overview of WASH / DRR in the development phase. It then explores the integration of WASH / DRR in the humanitarian and recovery phase in more depth. Methods and tools are presented that help staff in the integration of DRR in WASH actions.
- Annex 1 **The Pressure And Release (PAR) model:** presents a model used in DRR to assess and analyse hazards and vulnerability. This model assists in action planning by looking at how to address these issues.
- Annex 2 **The WASH Service Performance Framework:** a one-page framework that is useful for assessing the functioning of WASH services and to identify vulnerabilities.
- Annex 3 **Mitigation and preparedness measures for WASH systems:** presents the probable causes of specific hazard events, and describes the mitigation and preparedness measures that can be taken to reduce disaster risk.
- Annex 4 **Potential negative effects of WASH services on society:** looks at the possible issues that specific WASH services might create in a society. The effects are presented per WASH component and also look at measures that can be taken to avoid or reduce these effects.
- Annex 5 **Examples of DRR integration in WASH:** examples of projects where DRR elements have been integrated in emergency response and recovery interventions
- **References and further reading:** an overview of resources on WASH, disasters and DRR.

2 DISASTERS AND DISASTER RISK REDUCTION: CONCEPTS AND CONTEXT

2.1 DISASTERS AND DISASTER TRENDS

A disaster is an event where important losses and damage are inflicted upon communities and individuals, possibly including loss of life and livelihood assets, leaving the affected communities unable to function normally without outside **assistance**[2].

Figure 2 shows some recent trends with regard to natural hazard events.

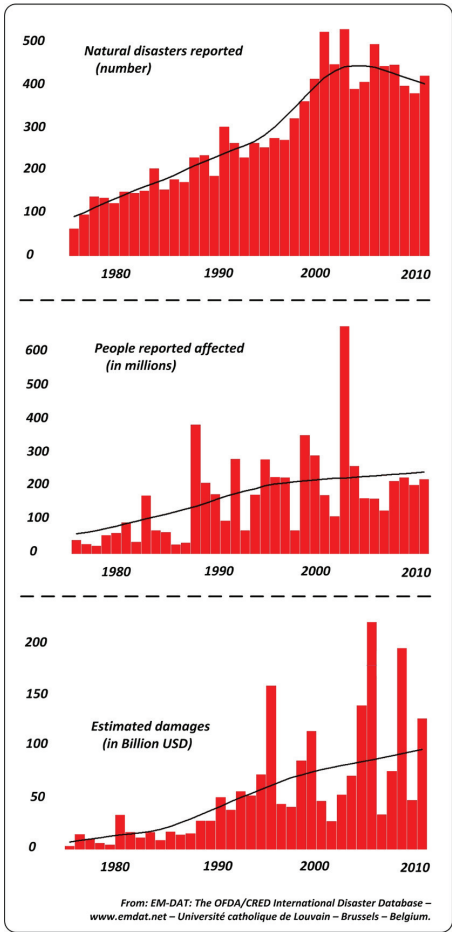


Figure 2: Number of events reported of, people affected by, and estimated damages caused by natural hazard events between 1975 and 2010[3]

2 The UNISDR (United Nations International Strategy for Disaster Reduction) definition of a disaster is 'A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources'.

3 http://www.emdat.be/natural-disasters-trends

The impact disasters have on human society is huge: between 2000 and 2008, on average around 400 disasters occurred per year, with on average over 215 million affected persons per year, and causing a total damage of well over 100 billion USD per year.
These figures don't always show the entire picture though - for example, Hurricane Mitch (which struck Central America in 1998) killed around 10,000 people but some of the countries hit by the hurricane may have had their development set back by as much as **50 years**[4].

The impact of disasters is mostly felt in developing countries, and within these countries it is the most marginalised people who are usually the most vulnerable to disaster impact. Disasters have a very strong negative effect on the impact groups (i.e. the poor, women and children) of the Millenium Development Goals (MDGs) and the services the MDGs target (e.g. schools, health services, environment). Disasters also put pressure on the achievement of the MDGs by diverting resources from development programmes to relief operations.
With the current rate of population growth, Climate Change, increasing urbanisation, environmental degradation and economic globalisation, it is expected that the rising trends in frequency and severity of disasters will continue. Many of the elements listed are mutually reinforcing and play at a global level.

2.2 DISASTER RISK

There is a risk of a disastrous event if two elements are combined

1. One or more hazards. A **hazard**[5] is a specific potential threat. Hazards can be 'natural' (e.g. earthquakes, floods, drought, cyclones, wild fires, extreme temperatures, etc.) and can be 'man-made' (conflict, industrial accidents, severe pollution, etc).
   Hazards are only threats - it is only when a hazard becomes a hazard event / process that damage is done.
2. A community that is vulnerable to this hazard. The **vulnerability**[6] of a community to a hazard is the extent to which people are lacking protection or buffering capacity against possible hazardous events or processes.

4 http://www.paho.org/English/DPI/Number6_article6.htm
5 The UNISDR definition of a hazard is 'A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage'.
6 The UNISDR definition of vulnerability is 'The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard'.

Thus a disaster occurs when a hazard event happens in a community that is vulnerable to this hazard event; this is shown in **Figure 3.**

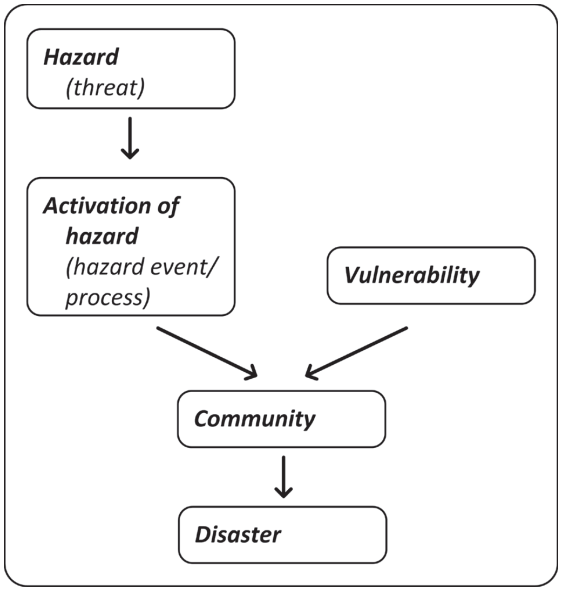


Figure 3: Elements needed for a disaster.

While hazard and vulnerability increase the risk of disaster, the **capacity**[7] of a society reduces the risk. This relation is often presented by the pseudo-formula:

$$\text{Potential impact on WASH system/ unit} = \frac{\text{Hazard exposure x Vulnerability}}{\text{Capacity}}$$

Sometimes exposure is added to the formula as a disaster can (by definition) only happen if a community is affected. This is the approach that will be taken with regard to WASH systems (see 3.3.1 Assessment, analysis and action planning in the recovery and development phases based on a worked example).

It follows from this formula that the disaster risk in a community can be reduced by bringing down the hazard threat and/or by decreasing vulnerability and/or strengthening capacity of a community. This is the field of Disaster Risk Reduction.

7 The UNISDR definition of a capacity is 'The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals'.

2.3 DISASTER RISK REDUCTION

Before the 1970s, disasters were largely seen as inevitable and emergency response and rehabilitation was seen as the way to deal with them . Over time, people started realising that it was possible to reduce the risk of disasters through structural, social and economic measures. Increasingly disasters were seen as the product of many factors that could be influenced in order to reduce risks.
The approach to disasters thus evolved from being reactive to being proactive, where a community and the risks it faces are looked at in a more holistic way. This resulted in a wide range of actions which became linked to the reduction of disaster risk. This pro-active, holistic approach became known as Disaster Risk Reduction (DRR).

DRR[8] is an approach where the likelihood and potential impact of disaster events are assessed by identifying and analysing hazards, the vulnerability of communities to these hazards, and their capacities to deal with events.

Following the assessment and analysis, there are several possibilities; shown in **Figure 4**

- The risk of a disaster occurring, and the expected impact, is medium to high, explicit DRR would be required to address the disaster risk. These are actions that specifically aim to increase the **resilience**[9] of society, communities and services.
- The risk of a disaster occurring, and the expected impact, is low to medium, explicit DRR would possibly not be justified, but DRR should be integrated in interventions that would be developed. In these situations there is no specific objective to increase the resilience of a community, but steps are taken to reinforce those improvements brought to the community against the effect of disasters.
- The risk of a disaster occurring, and the expected impact, are both low, During the planning phase it is not considered necessary to integrate risk reduction activities into the intervention.

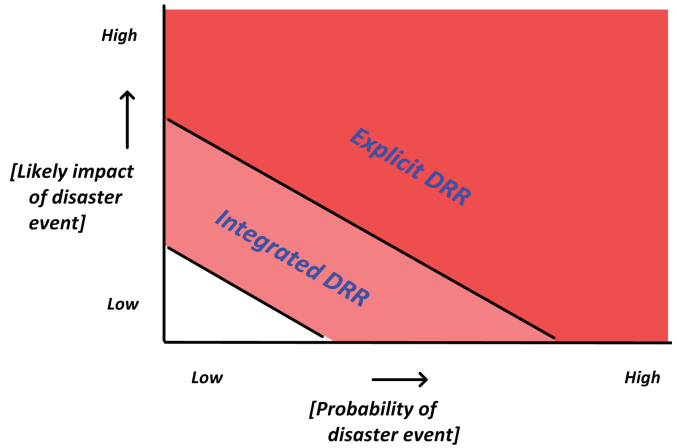


Figure 4: Probability of disaster against expected impact and type of action.

8 The UNISDR definition of a Disaster Risk Reduction is 'The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

9 The UNISDR definition of a Resilience is 'The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

Over time, disaster risk can change and this has to be monitored throughout the action. Even if initial probability and potential impact of a disaster are considered to be low. It might be that DRR activities would be required at a later point. Therefore disaster risk has to be monitored throughout the intervention.

DRR is a cross-cutting issue, and DRR actions will often integrate several sectors and other cross-cutting issues. To illustrate this: **box 1** presents activities that were developed in an explicit DRR project in Guatemala. The project was executed in slum communities and had a strong WASH component. Relatively few activities of this project were specifically linked to DRR, and many of these activities would fit just as well in a slum upgrading or WASH project.

Box 1 Example of activities of an explicit DRR project

Project developed in Guatemala aimed at reducing the risks of landslides and flooding in slum areas. List of activities with those highlighted in black being specific to disaster risk reduction:

- **Installation of a piped water supply**
- **Installation of a small-bore sewerage system**
- **Construction of stormwater drainage systems**
- **Building of retention walls**
- **Reforestation**
- **Building of communal halls**
- **Marking of evacuation routes**
- **Setting up a system of solid waste management**
- **Setting up an early warning system**
- **Hygiene promotion**
- **Capacity building in relation to disaster prevention / mitigation, preparedness and response**
- **Creation of a system of emergency response teams (e.g. emergency coordination, first aid, search and rescue)**
- **Improve the management and communication skills of community based organisations**
- **Reinforcement of social cohesion by development of group activities**
- **Reinforce the links between community and authorities**
- **Lobbying to improve the perception of the greater public and authorities on slums**

Every sector is linked to DRR: WASH, food security, shelter, energy, education, health services or the economy, all sectors are negatively affected by disasters. Breakdown in one sector can cause secondary disasters, and a proper functioning of the sectors is often the key to limiting the impact and extent of disasters.

In the international community the importance of the DRR approach is becoming increasingly recognized and so more attention is being paid to it. This has especially been the case since the Hyogo Framework for Action (HFA) in 2005, which was adopted by 168 member states of the United Nations, which had the overall goal of building resilience of nations and communities to disasters. **Box 2** gives a brief overview of this framework.

Box 2 The Hyogo Framework for Action

The HFA identified five priorities for action[10] :

1. Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation
2. Identify, assess, and monitor disaster risks – and enhance early warning
3. Use knowledge, innovation, and education to build a culture of safety and resilience at all levels
4. Reduce the underlying risk factors
5. Strengthen disaster preparedness for effective response at all levels

The timeline for the HFA was 2005-2015, and a significant reduction in disaster losses was aimed for in 2015.

While the HFA has had some limited success, mainly at national level, the effects at community level have been limited, and especially the most vulnerable have seen little improvement [11].

It is important to mention Climate Change here. For DRR to be fully effective Climate Change has to be integrated into the DRR approach. Climate Change will introduce new hazards (e.g. geographical spread of infections will change where new pathogens or vectors may be introduced in communities where they did not occur before, or regions that were not affected by tropical cyclones may be hit by these). Characteristics of hazards and hazard events may also change – for example, the probability of flooding or wildfire occurring in a location may increase, or the intensity of storms and floods may become stronger. The added pressure Climate Change will bring to livelihoods and society as a whole, will also increase the vulnerability, and decrease the capacity of communities with regards to dealing with disasters.

These changes will have to be considered in the assessment, analysis and planning of actions. The DRR approach has traditionally had a tendency to look backward to identify disaster risk and the impact disasters have had on society. With Climate Change it has become more important to look forward, to 'expect the unexpected', and to integrate scientific projection for Climate Change into intervention planning.

2.3.1 MAINSTREAMING DISASTER RISK REDUCTION

There is currently a push to mainstream DRR in programming. This means that the DRR approach will be systematically integrated into all relief, recovery and development actions. **Figure 5** shows what mainstreaming of DRR means in the project cycle.

10 http://www.unisdr.org/eng/hfa/docs/HFA-brochure-English.pdf
11 http://www.globalnetwork-dr.org/reports/VFLfullreport0609.pdf

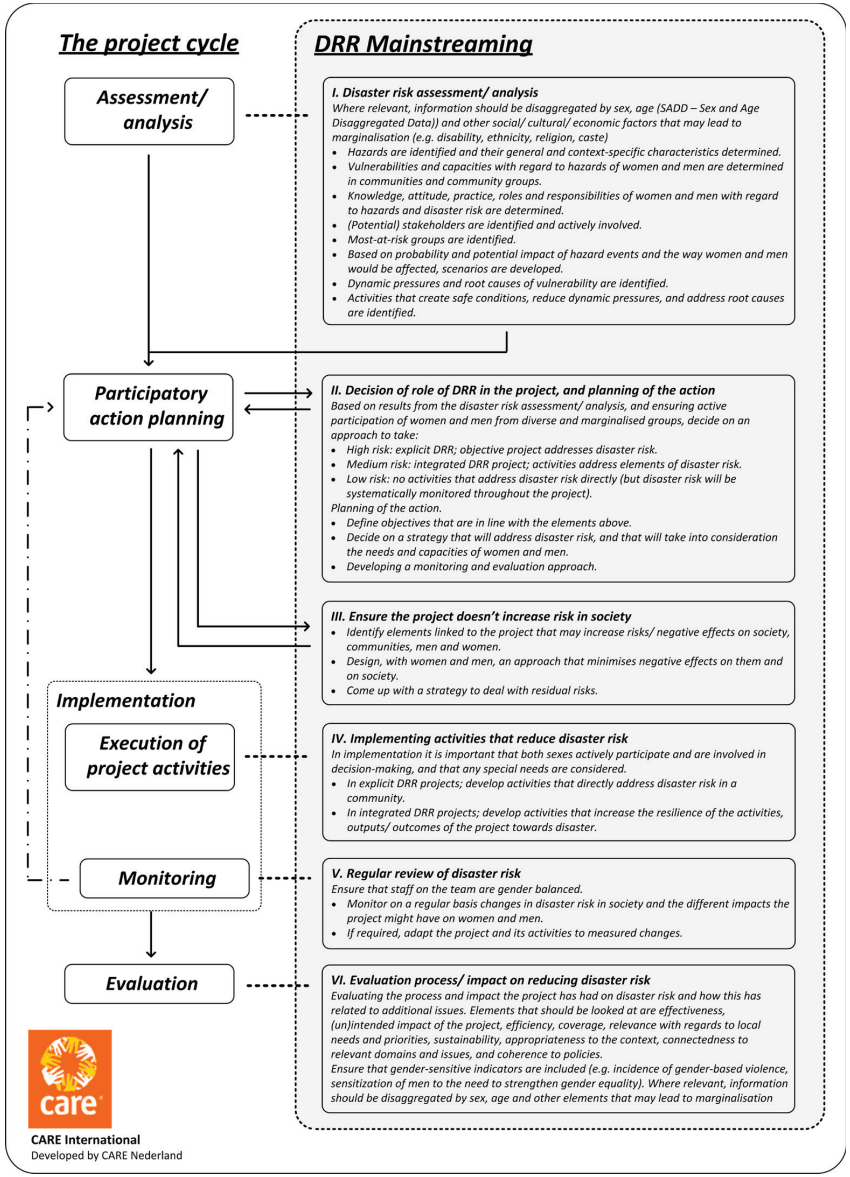


Figure 5: Mainstreaming DRR in the project cycle

2.3.2 DRR IN THE EMERGENCY MANAGEMENT CYCLE

Traditionally DRR has had a more developmental approach. DRR has its place in all phases of the emergency management cycle though (i.e. development, emergency relief and recovery). In emergencies the focus will be on 'life- and limb- saving' measures and on keeping critical services running and protecting these from new hazard events. The assessment and analysis will have to be simplified because of time and capacity limitations. In the recovery phase the aims of DRR will be: improvement of conditions in society, consolidating and securing critical services and beginning the consolidation of less critical services. Assessment and analysis will also be more thorough in this phase. In the development phase, DRR aims to look at all services, and a forward-looking perspective will be adopted - while the assessment and analysis will become more comprehensive.

All DRR measures fall into the categories of prevention / mitigation and preparedness

- **Prevention**[12]**:** measures needed to completely avoid the damage and/or disruption caused by a hazard to society. Because it is often difficult to completely exclude damage and/or disruption, and because a specific measure may prevent one event, and mitigate another (e.g. a stormwater drainage system may prevent flooding following rains that have a return period of 2 years, but not be able to prevent (though it will reduce the impact of) floods caused by rains with a return period of 3 years), in the guideline, prevention will be grouped with 'Mitigation'.
- **Mitigation**[13]**:** measures to reduce the impact of a hazard event to society. Some damage or disruption will happen, but the impact would be less than without mitigation measures. Some examples of mitigation measures could be reinforcing structures so damage will be more limited in case of a hazard event, or building in redundancy into a system.
- **Preparedness**[14]**:** all measures that can be taken to provide warning for hazard events that can potentially occur, to cope and deal with the effects of these event(s) and to get ready for the next phase in the emergency management cycle.

12 The UNISDR definition of Prevention is 'The outright avoidance of adverse impacts of hazards and related disasters'.
13 The UNISDR definition of Mitigation is 'The lessening or limitation of the adverse impacts of hazards and related disasters'.
14 The UNISDR definition of Preparedness is 'The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions'.

Box 3 'Mitigation' in DRR and Climate Change (CC)

The word 'mitigation' is used differently by DRR- and Climate Change- specialists. To avoid confusion it is good to understand the use of the two terms in DRR and CC.

The Intergovernmental Panel on Climate Change (IPCC) presents the following definition in the 'IPCC Fourth Assessment Report' for mitigation[15]: 'Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to Climate Change, mitigation means implementing policies to reduce greenhouse gas emissions and enhance sinks'.

Thus Climate Change specialists use the term mitigation for measures that will reduce the amount of discharged greenhouse gases and increase the potential to absorb these.

Measures to deal with the effects of Climate Change are called 'adaptation' by CC specialists. Contrary to DRR that only focuses on the negative effects of hazards, adaptation includes negative as well as potential positive effects. The definition for 'adaptation' in the 'IPCC Fourth Assessment Report is: 'Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected Climate Change effects. Various types of adaptation exist, e.g. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature-shock resistant plants for sensitive ones, etc.'

'Adaptation' measures taken in Climate Change Adaptation (CCA) actions and 'mitigation' measures taken in DRR actions are often the same or very similar.

Table 1 presents the different phases in the emergency management cycle with general type of DRR measures and examples.

Table 1: Phases in the disaster management cycle with example DRR measures.

PHASE	GENERAL SCOPE OF ACTION	SPECIFIC AIM AND EXAMPLES
DEVELOPMENT	Mitigation/ prevention	• Risk likelihood reduction: e.g. installation of dykes and levees, construction of stormwater drainage systems, reforestation of hills at risk of landslide • Risk consequence reduction: e.g. enlargement drainage channels, earthquake resistant construction, reforestation to reduce intensity run-off, immunisation, raising public awareness • Risk avoidance: proper land use management, relocation of households • Risk acceptance: acceptance of risk of light periodic flooding • Risk transfer/ sharing/ spreading: e.g. insurance, livelihood diversification

15 http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf

PHASE	GENERAL SCOPE OF ACTION	SPECIFIC AIM AND EXAMPLES
EMERGENCY RESPONSE	Preparedness	• Identification of hazard event warning signs: e.g. early warning system • Preparation for emergency response: e.g. development of a contingency plan, forming emergency response teams, capacity building of civil protection staff, prepositioning of supplies, building and maintaining community shelters, setting up resilient communication systems, raising public awareness • Preparation for recovery: e.g. capacity building in damage assessment, capacity building in more resilient reconstruction methods, preparation for disposal of debris, prepositioning of reconstruction materials
	Reduction of risk caused by service/ intervention	• Assessing the threats that the action may create and avoiding/ reducing the risks and negative impacts the action may create: e.g. avoid environmental degradation, avoid biological contamination of the human environment, proper disposal of waste, avoid constructions that are a physical threat to the population, organise traffic linked to service/ intervention to avoid accidents
	Mitigation/ prevention	• Risk likelihood reduction: e.g. installation of emergency structures to reduce disaster risk (e.g. make-shift dams, installing gabion systems to protect against erosion) • Risk consequence reduction: e.g. ensuring adequate WASH systems in place (e.g. improving existing or setting up parallel water supply, sanitation, vector control services), immunisation, raising public awareness • Risk avoidance: relocation of communities at risk • Risk acceptance: acceptance of increased risk of normally non-severe and non-acute infectious disease (e.g. schistosomiasis, conjunctivitis)
	Preparedness	• Identification of hazard event warning signs: e.g. early warning system for critical and imminent threats to community (e.g. dam failure, cholera outbreak) • Preparation for emergency response towards intensification and/or enlargement of primary disaster or of secondary disaster: e.g. capacity building of staff, prepositioning of key supplies, preparing community shelters and treatment centres, setting up resilient communication systems, raising public awareness • Preparation for recovery: e.g. damage assessment, planning for reconstruction taking into account and removing past vulnerabilities, acquisition of reconstruction materials
RECOVERY	Reduction of risk caused by service/ intervention	• Assessing the threats that the action may create and avoiding/ reducing the risks and negative impacts the action may create: e.g. reduce environmental degradation, reduce biological contamination of the human environment, adequate disposal of waste, avoid constructions that are a physical threat to the population, organise traffic linked to service/ intervention to avoid accidents
	Mitigation/ prevention	• Risk likelihood reduction: e.g. installation of dikes and levees, stormwater drainage systems, reforestation of hills at risk of landslide • Risk consequence reduction: e.g. enlargement drainage channels, reforestation to reduce intensity run-off, raising public awareness • Risk avoidance: proper land use management, relocation of households at risk • Risk acceptance: acceptance of risk of medium flooding, acceptance of increased risk of normally non-severe and non-acute infectious disease (e.g. schistosomiasis, conjunctivitis) • Risk transfer/ sharing/ spreading: e.g. livelihood diversification
	Preparedness	• Identification of hazard event warning signs: e.g. early warning system for medium severe and medium-range threats to community (e.g. light flooding, increased levels of non-severe epidemic infections • Preparation for emergency response towards intensification and/or enlargement of primary disaster or of secondary disaster: e.g. development of a contingency plan, forming emergency response teams, capacity building of civil protection staff, prepositioning of supplies, preparing and maintaining community shelters and treatment centres, setting up resilient communication systems, raising public awareness • Preparation for development phase: e.g. capacity building in damage assessment, capacity building in more resilient reconstruction, acquisition of materials needed to develop systems further
	Reduction of risk caused by service/ intervention	• Assessing the threats that the action may create and avoiding/ reducing the risks and negative impacts the action may create: e.g. avoid environmental degradation, avoid biological contamination of the human environment, proper disposal of waste, avoid constructions that are a physical threat to the population, organise traffic linked to service/ intervention to avoid accidents

3 DRR AND WASH SERVICES

Some sectors are critical to survival and to the functioning of society, and it is crucial that these sectors remain functional under all conditions. WASH is one of these. Inadequate WASH services can cause disasters, and disasters can further degrade WASH services, resulting in increased disaster risk. It is therefore necessary to consider disaster risk when setting up or developing WASH services, whether in the emergency response, early recovery or development phase. It is also essential that new vulnerabilities or hazards are not introduced or reinforced through existing or new WASH services.

Figure 6 shows two areas of concern where WASH services can relate to disaster risk.
Disasters can directly disrupt service levels of WASH facilities to society (existing or part of the emergency response), resulting in increased risk. For example, an earthquake may rupture water distribution pipes, and the water supplied may become contaminated, increasing the risk of outbreak of faecal-oral infections. This will be the first focus taken in this guideline: how to ensure that effects of hazard events are mitigated through explicit activities that mitigate against and prepare for disaster. An essential element of this is consistent application of good programming and engineering practice, and some organisations consider the development of general WASH in emergencies already as DRR.
Inadequate WASH services can lead to disasters. A community using river water that is faecally polluted by upstream communities will be at risk of an outbreak of faecal-oral infections (e.g. typhoid fever, cholera). Stormwater drainage systems that cannot remove the water generated by heavy rains, because of poor design or blockage by soil or solid waste, may cause flooding of communities. This guideline will not go this far, and the approach taken here will be to make WASH systems resilient against natural hazard events.

The second focus will be on ensuring that WASH services, either previously existing or created by the emergency response, do not create new (secondary) disaster risks by causing conditions that are favourable to disasters. This includes risks created by the 'normal' functioning of the system, as well as risks generated by effects a disaster may have had on a WASH system (e.g. contamination of the environment by sanitary structures during flooding).
Disasters can easily destroy or degrade WASH services, which may create conditions that can lead to follow-up, or secondary, disasters. A community displaced because of flooding, and living in crowded and unhygienic conditions, may be at risk an outbreak of cholera, louse-borne typhus and other infectious diseases. A disaster that damaged the water supply used for irrigation may result in loss of livelihood opportunities in the community, leading to poor food security.

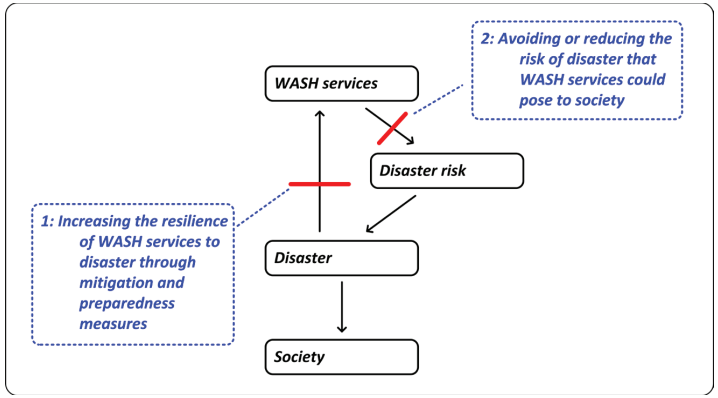


Figure 6: DRR and WASH services: approach used in this guideline

Disasters and WASH services are linked in many ways. WASH is critical for the survival of individuals, society and for the maintenance of livelihoods.

It is important here to keep the big picture in mind. In any action the links with other sectors (e.g. shelter, food security, energy, health services) have to be considered and priority given to the sectors that can maximise positive impacts on society.

3.1 INTEGRATION OF DRR IN WASH IN THE DIFFERENT PHASES OF THE EMERGENCY MANAGEMENT CYCLE

The focus of DRR in the different phases of the WASH emergency management cycle will vary, even though the general approaches (i.e. mitigation and preparedness) will be largely similar across phases.

- Because of the nature and priorities of **emergencies**, and lack of time and resources in the emergency phase, DRR will be limited in scope. In relief, the focus will be on critical services, ensuring users have access to enough clean water for their survival needs. DRR actions will be limited to essential elements (e.g. safe location of emergency system, or ensuring sufficient stock and safe storage of water treatment chemicals). The timescale considered will probably be narrow, ranging from hours to weeks. Integration with other sectors and cross-cutting issues will also be more limited.
- In the **recovery** phase, there is a certain stabilisation and the boundaries are enlarged. While the elements covered in relief remain important, services covered will be extended to less critical but key services (e.g. solid waste management where presence of waste might pose a risk to public health). DRR actions will be larger in scope, and will aim for higher levels of resilience. Timescale considered will be extended to possibly months or entire seasons. The integration with other sectors and cross-cutting issues will also become much stronger.

- In the development phase, the elements of the relief and recovery phases are covered but in an expanded form. All WASH services are covered, including non-critical ones (e.g. solid waste management where the presence of solid waste is not considered a large public health or safety issue). DRR actions will be comprehensive, and will aim for a high level of resilience, especially for critical WASH services. Timescale considered will be long: multiple years. Integration with other sectors and cross-cutting issues will be significant.

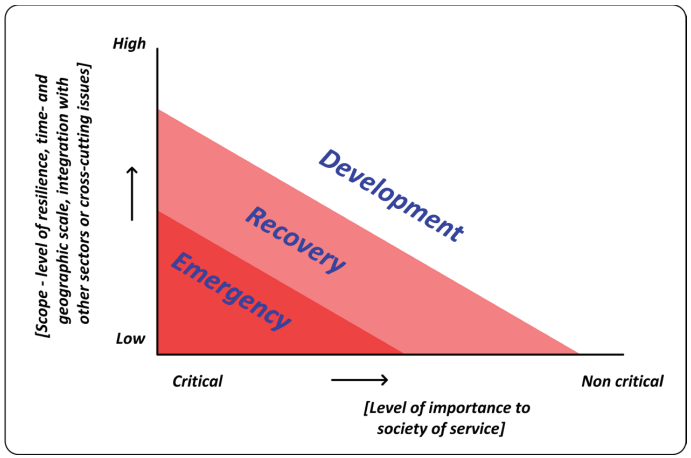


Figure 7: Focus of DRR in the different emergency management cycle phases.

There are some aims of WASH interventions that are relevant to all phases of the emergency management cycle, and these are presented below.

The aims of DRR in all the phases are

1. To reduce the potential impact of hazard events on WASH services (i.e. mitigation)
2. To ensure a rapid service level and structural recovery of WASH services after hazard events (i.e. preparedness)
3. After damage by hazard events, to ensure that the design of the systems addresses earlier vulnerabilities resulting in more resilient services (i.e. 'build back better')
4. To ensure that WASH services have minimal negative effects on society (i.e. do no harm)

These aims will be discussed below in more detail.

3.1.1 TO REDUCE THE POTENTIAL IMPACT OF HAZARD EVENTS ON WASH SERVICES (I.E. MITIGATION)

Prevention / mitigation measures aim to avoid damage or disruption of the WASH services. Different approaches can be used to achieve this

- The first approach is to reduce the likelihood of risk events occurring. Here measures are taken that will reduce the chance that a hazard occurs, or that isolate the hazard event from the WASH system. An example is a stormwater drainage system that will remove water from an area in a controlled way, thus avoiding flooding.
- The second approach is to reduce the consequences of risks. It is assumed the hazard events will happen, but measures are taken to limit the damage done. An example would be where structures are reinforced or upgraded so they become more resistant to the effects of an earthquake – in this case, it is likely that there would still be damage, but it will be more limited. Another example would be to train a number of pump caretakers in a village so that if one of them is not able to work, others can take over.
- An alternative approach is risk avoidance. Here, the threat is removed by avoiding exposure. An example would be to avoid the installation of structures in areas at risk of flooding or landslides.

There are two other approaches that are strictly speaking not mitigation of disaster risk, but that are often included under mitigation

- Risk acceptance: here, the risk cannot be addressed adequately, and the damage or disruption that might follow a hazard event is accepted. An example could be a stretch of pipeline that runs through an area at risk of landslide. Another example would be storm water drainage systems that are designed for storms with certain return periods, where the risks brought on by storms with higher return periods are accepted. Occasionally there is no other option than to accept the risk. Sometimes this problem may be overcome by building redundancy into the system, so that if one component is lost, another can take over. Where potential (partial) loss is a risk, preparatory measures will usually be needed. An example would be to plan for transporting water by truck to communities that would be at risk of being cut off from a piped water supply system.
- Risk transfer, sharing or spreading: Here, (part of) the risk is spread or shared with someone else. Examples are insurance, or working out an agreement with communities to allow other communities access to a water source if there is a breakdown of one system.

The application of standards and general good practice for WASH services ensures that many mitigation measures will already have been implemented. Where there is a risk, and it is not clear whether applicable standards would be adequate, an in-depth investigation of disaster risk will almost certainly be needed. While WASH specialists will often be able to adequately assess and analyze hazards and vulnerabilities of basic small-scale community-based WASH systems, more complex services like a large urban water treatment plant at risk of earthquake, will most likely need specialist advice.

Examples of mitigation and preparedness measures can be found in Annex 3: Mitigation and preparedness measures for WASH systems.

An interesting approach used for water supply systems are Water Safety Plans; **Box 4** describes the approach in summary form.

Box 4 Water Safety Plans[16]

Water Safety plans (WSP) approach water supply systems in a similar way as described in this guideline. The focus of most resources on Water Safety Plans is specifically on water quality. There are also resources that take a more holistic approach[17]. This makes sense as water quality is only one of the elements that affect users, user satisfaction and health. As most resources focus on water quality this approach is discussed here.

Water Safety Plans can be used for water supply of any scale, and can be made for existing and new systems.

The main aim of a WSPs is to minimise, and remove, contamination effectively throughout the entire process before consumption of the water.

A Water Safety Plan consists of three elements:

- An assessment of every individual component in the water supply, from source to user, to determine whether there is a risk to water quality.
- A system of systematic monitoring specific parameters to rapidly detect any issues.
- Processes to correct any issues that would arise, monitoring of the plan, and reporting.

The plan uses a systematic and holistic approach and will normally involve all stakeholders that potentially have an impact on water quality (e.g. engineers, water managers, users, public health specialists). Water Safety Plans are normally the result of an in-depth study involving a large number of stakeholders, and will be made in a stable situation. The assessment and analysis is much more comprehensive than would be possible in the emergency response phase, and possibly even in a recovery phase.

In 'References and further reading' resources are included that explain the concept of water safety plans, and that describe the approach taken.

3.1.2 TO ENSURE RAPID SERVICE LEVEL AND STRUCTURAL RECOVERY OF WASH SERVICES AFTER HAZARD EVENTS (I.E. PREPAREDNESS)

Preparedness measures aim to identify approaching potential hazard events, to cope with the immediate effects of an event, and to recover as quickly and effectively as possible from the damage done. Emergency preparedness measures include:

1. Creating an Emergency Preparedness Plan (EPP). This plan describes in detail the strategy and organisation of dealing with specific hazard events, and how to recover from the negative effects of an event, and will include resourcing, monitoring and evaluation processes. An example of the contents of an EPP is presented in **Box 5.** For basic systems the plan can be simpler, whereas for critical services and larger systems, comprehensive EPPs should be made. In planning the response to the emergency it is important to link with other services and organisations that have a role to play (e.g. public health services, fire department). The strategy of the plan will have to be adapted to the real capacity and commitment of external bodies that will be involved in the relief and recovery strategy.

16 http://www.who.int/water_sanitation_health/dwq/GDW4revrev1and2.pdf
17 http://www.who.int/water_sanitation_health/publication_9789241562638/en/index.html

An EPP can be made for a specific WASH service, an organization, or a whole society. If an EPP is made for a specific WASH service it should be in line with other plans that have been made and apply locally (e.g. municipal plans).
A plan is only as good as its application, and to be effective a clear organisational structure, competent people, adequate assets, effective procedures and resources, and (political) support and commitment will all be needed for the EPP to function properly. The EPP will need to be revised regularly so it remains up to date.

Box 5 The Emergency Preparedness Plan

An example of the contents of an EPP for a WASH system:

- Description of the WASH system with special attention to vital elements in the system
- Scenarios for different hazard events describing hazard characteristics, location, intensity, probability, early warning signs, duration
- Forecasts on how these events will affect the WASH system
- Forecasts of how possible damage to the WASH system will affect the service levels of users
- Description of potential new risks, or changes in existing risks, that could develop following the scenarios
- Description of aims of the contingency strategies (e.g. maintain minimum service levels to users, rapid recovery)
- Description of contingency strategies and their triggers; included will also be alternative strategies on how to maintain minimum service levels, and triggers for when these strategies will be activated
- Description of measures that can be taken to reduce the probability and/or impact of hazard events (i.e. mitigation and preparedness measures)
- Description of risk monitoring strategies (e.g. early warning system)
- Listing expected timescales of development of different strategies
- Listing internal and external stakeholders that play a role in DRR and emergency response with contacts with their roles, responsibilities and real capacities with regard to the WASH system
- Hierarchy, procedures and systems that will be activated in case of different scenarios, this also includes communication strategy (e.g. notification, reporting) and release of back-up resources
- Description of assumptions and risks with regards to contingency strategies
- Description of possible liability issues (e.g. loss to private sector because of service breakdown) and how they will be dealt with
- Describe other emergency management systems present in the target area and assessment of the potential to link to these
- Listing of dedicated resources for emergency response and their location (e.g. stockpiled materials for emergency response)
- Definition of resources needed for maintaining the contingency strategies
- Definition of where resources for set-up and maintenance of contingency strategies will be obtained
- Description of monitoring and evaluation processes
- Description of process to keep the EPP up to date

2. Developing an organizational structure that can make the emergency preparedness strategy work. For small-scale, simple WASH systems this structure may be very basic. For larger systems this structure may consist of task forces taking on emergency coordination, search and rescue, first aid, psychosocial support, and logistics.
   Depending on the type, size and organisation of the WASH service and the context, the organisational structure may entirely consist of community members and workers of the service; equally, it may include people from the authorities, and possibly from the private sector.
3. Building capacity. People who will be part of the contingency strategy will need to have adequate knowledge and skills. These tasks may require new skills: coordination or supervision skills, damage assessment, use of communication equipment, first aid, dealing with chemical waste, search and rescue. Equipment must be familiar to potential users, and procedures and personal safety measures have to be known.
   Besides individual skills, people will need to become familiar with working in a team and with the new rules that may apply. Building capacity and maintaining it will need regular training and simulation exercises.
4. Making materials and infrastructure available. Specific materials are needed for emergency response. What is needed depends on the service, context and type of disaster. Some examples of materials and infrastructure that may be needed include buildings used for shelter, emergency water tanks, containers for household water storage, materials for distribution of water, water disinfection chemicals, pumps, generators, means of transport, fuel, spare parts, communication equipment, security materials, construction materials, medical supplies, and places to dispose of waste. The exact needs in infrastructure and materials should be identified in the contingency plan. A yearly budget has to be allocated for preparedness and contingency planning. It will be difficult to obtain funds for preparedness especially if disasters are unusual, not a political priority, or if resources are scarce. Lobbying activities may be needed to raise the awareness for this.
5. Setting up an Early Warning System (EWS). An EWS can give advance warning of imminent threats, and it should trigger measures that will reduce the potential impact of an event. There is significant value of a good EWS for society as a whole, and where possible, such an EWS should be set up. On a more limited scale, a smaller scale EWS may be adequate for WASH systems (e.g. a basic system that warns an operator if there is an imminent threat of flooding of a water intake).

3.1.3 TO ENSURE THE DESIGN OF THE SYSTEMS ADDRESSES EARLIER VULNERABILITIES

Services that have been damaged in disasters are often rebuilt or set up to the same standard as before the disaster. This usually means that the system is as vulnerable as it was before the event. Therefore during the rehabilitation of services, the vulnerabilities that led to damage or collapse have to be identified, and the resilience of the service has to be improved to avoid the same problem from occurring if a new hazard event would occur. This is the 'build back better' principle. One example could be to raise handpumps or well heads so that they are clear of flooding **(see Figure 8)**. Sometimes disasters also generate new vulnerabilities that will have to be considered.

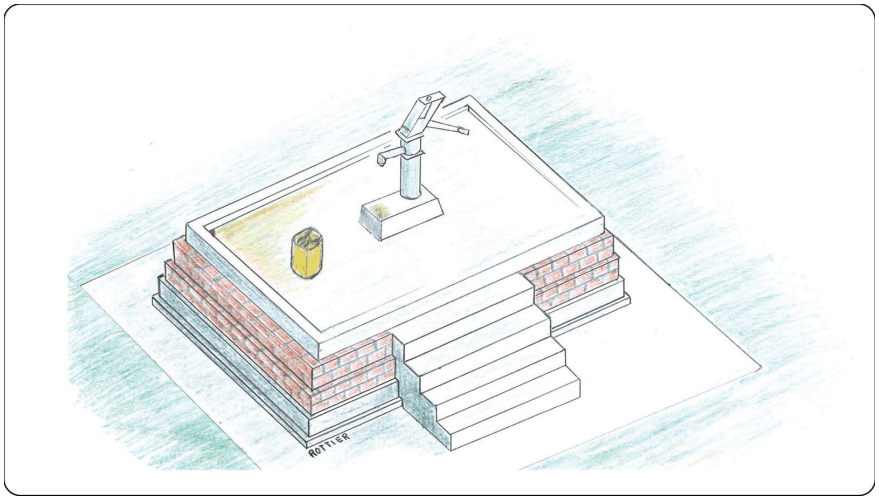


Figure 8: Raised handpump for flood-prone areas

3.1.4 TO ENSURE WASH SERVICES HAVE MINIMAL NEGATIVE EFFECTS ON SOCIETY (I.E. DO NO HARM)

WASH services can have a negative impact on communities by causing degradation of the environment, contamination, by posing a direct threat (e.g. collapsing structures), or by causing issues like degradation of roads, traffic congestion, and nuisance through smell or noise.

The services will have to be assessed against the negative effects they could cause, and measures will have to be taken to minimise issues. This is the 'do no harm' principle. More information on this, and potential measures that can be taken to avoid or control these are listed in Annex 4: Potential negative effects of small-scale WASH services on society.

3.2 INTEGRATION OF DRR IN THE EMERGENCY RESPONSE PHASE

The emergency response phase is the period just before, during, and after the hazard event. If there is a forewarning of an approaching event, the emergency response may start before the event occurs. The priorities in this phase are avoiding loss of life and injury, limiting damage to assets and environment, and preparation to recovery. This phase will last until the situation is in some measure stabilised, mortality brought back to an acceptable level, imminent threats controlled and where recovery can start. Depending on the situation, the emergency response phase typically last from some weeks to some months.

The aims of DRR with regard to WASH in the emergency phase are:

1. To maintain adequate service levels through the reduction of the impact of potential hazard events on existing WASH services.
2. To set up resilient emergency WASH services.
3. To ensure rapid service level and structural recovery of WASH services after hazard events.
4. To ensure WASH services have minimal negative effects on society (i.e. do no harm).

3.2.1 ASSESSMENT AND ANALYSIS IN THE EMERGENCY RESPONSE PHASE

A proper assessment is critical to the success of the action. Time is very limited during an emergency response and a balance has to be found between simplicity / rapidity on the one hand, and reliability / comprehensiveness on the other.

In the initial stages of the response phase the focus will be on critical WASH services. What these are will depend on the situation. Assuring that people have access to their needs for survival in water and household water storage is an obvious priority. The second priority would be to ensure that any major threats to public health are addressed - examples include limiting faecal contamination of the environment, increasing water availability and access to soap, or control of vectors where vector-borne infections are a potential issue. The initial assessment will normally identify the specific priorities in a given context.

The emergency context is, almost always, complex. Response teams suffer from extreme workloads and stress levels are usually high, so simplicity of approach has an added value.
Adding new tools or procedures should, where possible, be avoided, and the most adequate approach is to integrate DRR elements into existing procedures. What follows is an overview of how DRR can be integrated into WASH actions in emergencies by incorporation into existing systems.

ASSESSMENT IN HUMANITARIAN PHASE

Who
WASH staff involved in emergency response

When
During the community baseline and WASH needs assessment. The availability of time for producing the results of the assessment is limited (hours to some days). An in-depth assessment is not possible. The main issues should be reliably identified in a short time-span. More detail will have to be progressively added.

Methodology
The assessment of disaster risk will be integrated in the community baseline and WASH needs assessment. Potential methods are:

- Study of secondary data
- Rapid technical and organisational assessment of WASH services
- Measurements on WASH system
- Direct observation
- Rapid mapping
- Transect walk
- Semi-structured interviews

The approach should be as participatory as possible within the limitations of the situation

Results
The assessment and analysis should produce the following results:

- A succinct overview of hazards that may impact critical WASH services with potential scenarios of how these may affect services (existing or emergency)
- A concise outline of the state of critical WASH services (existing or emergency) with their vulnerability towards hazards
- A brief review of disaster risks the WASH services (existing or emergency) might introduce into communities

Additional questions will have to be integrated into the existing checklists, such as those outlined below. Annex 2: The WASH Service Performance Framework presents a framework that can be used to assess WASH services, and more information on possible harm to communities can be found in Annex 4: Potential negative effects of small-scale WASH services on society.

WASH SERVICES

WASH services
- What WASH services are critical to survival and/or prevention of major public health issues?
- What WASH services are essential to the conservation of livelihoods?

Hazard assessment
- Are there hazards that might affect critical WASH services?
- What is the probability that a hazard event will occur?
- If a hazard event occurs, what is the potential impact on critical services?

Institutions and organisations:
- What institutions and organisations play a role in the emergency response?
- What role should these institutions and organisations play in the emergency response?
- What support can realistically be expected from these institutions and organisations?

For critical WASH services:
- Using WASH performance framework from Annex 2: The WASH Service Performance Framework:
  - What key elements have been affected in the disaster?
  - What is the impact on the functioning of the service?
  - Are there obvious elements that functioned poorly before the disaster?
  - What is the impact on the functioning of the service?
- How has the disaster affected the service level of users, are specific groups particularly hit?
- Using the framework from Annex 3: Mitigation and preparedness measures for WASH systems:
  - Are there measures that can realistically be taken within (a) some days and (b) some weeks to improve service level (i.e. quality, quantity) and reliability of existing services as well as on potential emergency services?

For all existing WASH services:
- Are there any elements of the services that negatively affect communities; are specific groups particularly hit?
- Are there measures that can realistically be taken within (a) some days and (b) some weeks to reduce the negative effects?

For emergency WASH services being set up:
- Are there any elements of the emergency services that could negatively affect communities; would specific groups be particularly hit?
- What measures have to be taken to eliminate or reduce the negative effects to acceptable levels?

Some basic hazard maps indicating areas most at risk, or additional supporting material (e.g. photos, situation sketches, process diagrams) could be added if relevant.

The disaster risk in the target area will not remain constant over time. The initial assessment cannot be very thorough and, over time, a better understanding of the disaster risk situation will be needed. Assessments and analysis on WASH will be continuous in the humanitarian phase, and these initiatives should be used to continue to obtain more detail of disaster risk in relation to the WASH services. Depending on the advance of the emergency and the context, the approach should evolve towards the methodology described under DRR in the WASH recovery phase.

The results of the assessment need to be analyzed and incorporated into action planning.

3.2.2 ACTION PLANNING IN THE EMERGENCY RESPONSE PHASE

With the results of the assessments (community baseline, WASH needs, and disaster risk assessment) and the analysis of these results, an action plan will be made. This plan will focus on restoring / maintaining critical WASH service levels. The plan should also ensure that WASH services, both existing and emergency services, will not result in additional disaster risk. Action planning should be as participatory as is practically possible involving the most vulnerable, and should as much as possible protect and build upon existing beneficial organisational structures.

Many measures can be taken to reduce the risk of disaster in the emergency response phase. A complete listing of measures that can be taken is presented in Annex 3: Mitigation and preparedness measures for WASH systems. While the focus of these annexes is on the recovery and development phases, many measures are also applicable, or can be adapted, to the emergency phase.

SERVICE TYPES	EXAMPLES OF MEASURES
Existing services	**Infrastructure** • Strengthening infrastructure (e.g. bracing structures to avoid collapse, change poor quality or worn-out parts for good quality new ones, build sandbag wall to protect small slope from erosion/ collapse, protect intakes) • Build structures or systems that will reduce the impact of possible hazard events on WASH components (e.g. gabion systems to reduce energy of water, installing fire breaks) • Build in structural redundancy (e.g. install a second water intake, organise access to alternative workshops) **Human resources** • Staff capacity building (e.g. training staff in damage assessment and repair, ensure redundancy in staff (i.e. several persons have the same skills), train staff in safety and security) **Materials** • Create/ prepare redundancy (e.g. prepositioning of back-up generator, diesel motor-pump, ensure spare capacity in transport) • Increase autonomy (e.g. prepositioning of spares, consumables, tools at the place where they will be needed, preposition materials needed for possible repair, ensure adequate stocks of spares and consumables are present) • Ensure materials and equipment are protected (e.g. against flooding, high wind, high temperatures, fire, theft) **Organisation** • Put in place a reliable and appropriate system of monitoring of service level quality, and ensure there is capacity to intervene if standards are not met • Set up systems that facilitate functioning (e.g. procedures for release of materials, direct communication procedures) • Setting up emergency early warning systems for critical and imminent threats (e.g. dam failure) **Inputs** • Work out a way to deal with increased expenses, and possible reduced income (e.g. agreement with municipality) • Prepare for changes in water quality (e.g. identify possible issues in water quality, install supplementary reservoirs that can be used for assisted sedimentation or chlorination) • Prepare for reduced availability of water (e.g. prepare access to alternative water sources) • Ensure security in supply of critical consumables, spare parts and equipment (e.g. through contracts with suppliers, increasing stock levels)

SERVICE TYPES	EXAMPLES OF MEASURES
Emergency WASH services (may be partly integrated into existing systems)	**Users** • Prepare for change in demand (e.g. increased demand because of firefighting, demand at different location because of population displacement) • Prepare for change in attitude of users (e.g. strengthen ties with traditional power structures, communication campaign directed toward users) **External infrastructure & service providers** • Avoid dependence on specific supplier (e.g. identify alternative suppliers, obtain quotes) • Secure rents or loans (e.g. ensure contracts that have local value, look for alternatives) • Reduce dependence on services that might be vulnerable (e.g. ensure back-up energy through generators, set up alternative communication through VHF system) • Avoid dependence on specific external specialists if loyalty might be an issue (e.g. look for alternative specialists, obtain quotes) **Other** • Adapt to changing context (e.g. provide protection to staff) **Many measures mentioned above are also applicable to emergency WASH services, some additional measures are mentioned:** **Infrastructure/ materials** • Ensure safe location (e.g. areas above the expected floodline, away from buildings or structures at risk of collapse, in areas safe from landslide) • Use quality structures and materials that have a high resistance to hazard events that might occur. • Design systems so they have built in redundancy (e.g. several parallel reservoir systems that allow individual reservoirs to be isolated from the system, back-up equipment like generators and motorpumps are in place, connection to second borehole, installation of second water intake) **Human resources** • Staff capacity building (e.g. training staff in proper use of systems) **Organisation** • Set up and maintain systems adapted to existing services, organisation and context **Inputs** • Prepare the system for possible changes in water quality (e.g. build in extra capacity in assisted sedimentation system) • Build the system to reduce the needs for consumables that might be difficult and expensive to obtain (e.g. if adequate, install roughing filter system instead of assisted sedimentation, where possible use gravity instead of pumping) **Users** • Adapt service to the needs of users (e.g. ensure structures are adapted to local customs and preferences, ensure minimum chlorine levels) **External infrastructure & service providers** • Avoid dependence with regards to specific suppliers, services or specialists (e.g. use systems that have low need for external supplies, services or specialists)

When planning logical frameworks, it is unlikely that the objectives of humanitarian aid actions would be explicitly focussed on the reduction of disaster risk. The disaster risk reduction component should preferably be integrated into an objective that has a different focus (e.g. a health-related objective). However, under 'results' or 'expected outcomes' of the logical framework, disaster risk can be integrated in specific lines.

Below is an example of a part of a logical framework that would integrate DRR in a WASH action in emergency response. The example shows that DRR integrates easily into existing WASH programming and that, to a large extent, it is already integrated into standard WASH actions. What is new is the integration of a future perspective on potential hazard events.
In this example, flooding in an area has caused damage and contamination of existing boreholes, and there is a risk of outbreak of faecal-oral infections. DRR elements are in black.

OVERALL GOAL	INDICATORS
Purpose: Risk of disease transmission in community x is reduced through installation and maintenance of effective and resilient water supply, excreta disposal, and hygiene promotion systems.	**Indicators:** • Sphere standards have been met for relevant services throughout the period x • Services have adequately been maintained for 98% of the time throughout the period x • …
Results: **1.** Existing water supply systems are rehabilitated and able to withstand short-term flooding as caused by floods over the period x **2.** …	**Indicators:** • … • Installation standards for boreholes allow for short-term flooding as caused by earlier floods without degradation or contamination of the system
Activities: **1.1** Clear borehole of sediments and redevelop **1.2** Reseal top of borehole with clay sanitary seal **1.3** Repair or install drainage apron, headwall, drainage system and fencing **1.4** Disinfection of borehole **1.5** Install wellhead that excludes water when flooded …	**Inputs:** • …

It is assumed that possible negative effects and risks WASH actions could bring have been considered in action planning, and these are not included in the logical framework.

3.3 INTEGRATION OF DRR IN THE RECOVERY AND DEVELOPMENT PHASES

Recovery starts in the emergency response phase after some stabilisation has been reached. The uncertainty that usually surrounds emergencies makes it difficult to define when recovery begins. It is also difficult to know exactly when recovery ends. Many societies are constantly affected by hazard events and exist almost continuously in the emergency response / recovery phase. The recovery phase is for rebuilding the livelihoods and services of communities to a pre-disaster level and forms a preparatory basis for the development phase that follows.

In the development phase, conditions in a society are relatively 'stable' or improving (e.g. relating to security, livelihoods, and governance). In general the priorities in the development phase are sustainable growth, or alternatively, consolidation of the growth that has been achieved.

The aims of DRR for both the recovery and development phases are:

1. To reduce the potential impact of hazard events on WASH services (i.e. mitigation).
2. To prepare for the rapid recovery of the service level of WASH services after hazard events (i.e. preparedness).
3. After damage by hazard events, ensure the design of the new or adapted systems addresses earlier vulnerabilities (i.e. 'build back better').
4. To ensure WASH services have minimal negative effects on society (i.e. do no harm).

3.3.1 ASSESSMENT, ANALYSIS AND ACTION PLANNING IN THE RECOVERY AND DEVELOPMENT PHASES BASED ON A WORKED EXAMPLE

The assessment in the recovery phase is much more thorough than the one during emergency response, and the persons doing the assessment will have to be more familiar with the DRR methodology.

ASSESSMENT IN RECOVERY AND DEVELOPMENT PHASES

Who

WASH staff with experience in Disaster Risk Assessment. As the process will gradually become more technical and participatory (depending on the WASH service, involving community, staff from service provider, authorities), persons with relevant skills will have to be involved in the assessment.

When

Disaster Risk Assessments will have to be carried out as soon as possible in the response phase. Disaster risk will have to be monitored regularly to be able to address issues that emerge.

Methodology

Potential methods are:

- Study of secondary data
- Technical assessments / site inspections
- Organisational assessments including human resources, logistics, administration, procedures, user attitude and capacity, externals
- Measurements on WASH system
- Interviews
- Focus groups
- Seasonal calendar
- Historical profile
- Ranking
- Venn diagram
- Institutional and social network analysis
- Direct observation
- Mapping exercises
- Transect walk

The approach should be as participatory as possible within the limitations of the situation

Results

The assessment and analysis should produce the following results:

- Scenarios of how hazard events may affect WASH services (existing or emergency)
- Scenarios on how damaged WASH services will affect society
- A prioritisation of WASH services that need attention
- An overview of disaster risks the WASH services (existing or emergency) might introduce into communities

In order to visualise this process. a comprehensive example of integrating DRR in WASH in a fictional village "La Esperanza" is presented. This example looks at all parts of the process from assessment through to action planning. The steps in the process are illustrated in **Figure 9.** In this example existing systems are looked at; the same approach can be taken when new systems are designed.

Methods used for hazard assessments can include interviews, focus group discussions, transect walks and direct observation, seasonal calendar historical profile and organizational analysis.

In this example, the methods used for assessing disaster risk were

- Interviews with community leaders, several community members, authorities, and a research institute
- Direct observation of the area and the WASH services
- Focus group discussions
- Mapping exercises
- Seasonal calendar
- Historical profile

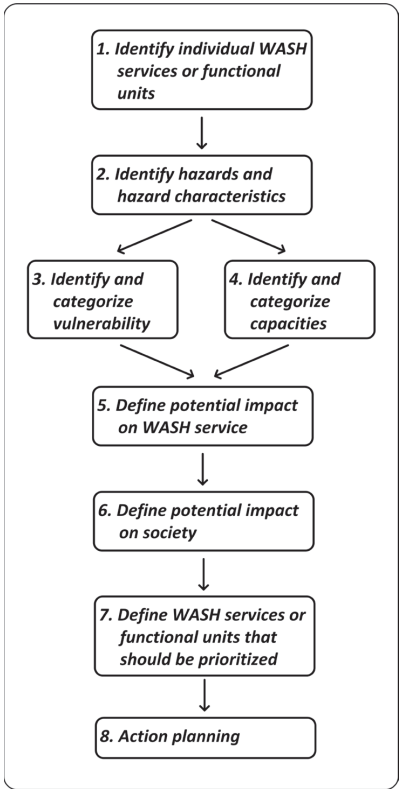


Figure 9: Steps in assessment, analysis and action planning.

1. **Identify individual WASH services or functional units**
The first step in the process is identifying the individual components of WASH systems that have to be looked at in the target area. This can be individual systems in specific locations (e.g. handpumps, latrines, protected spring); for more complex systems, individual components of these systems have to be identified (e.g. surface water intake, pumping station, roughing filter unit, stretch of pipeline). For interdependent systems, a flow diagram can be made to make the functioning and interdependencies clear. **Figure 10** presents an example.

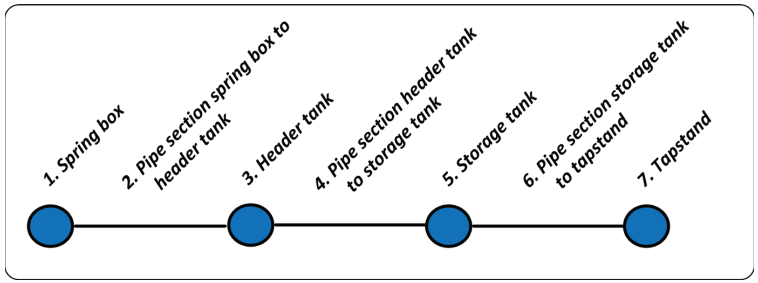


Figure 10: Overview of components of the gravity-fed water distribution system

In the table below the separate individual WASH systems that were identified in La Esperanza are shown, and where possible the individual components of these were listed.

Table 2: Overview of WASH systems of La Esperanza.

INDIVIDUAL WASH SYSTEM	NO.	INDIVIDUAL COMPONENTS OF WASH SYSTEMS
A- Gravity-fed water distribution system	1	• Spring box
	2	• Pipe section spring box to header tank
	3	• Header tank
	4	• Pipe section header tank to storage tank
	5	• Storage tank
	6	• Pipe section storage tank to tapstand
	7	• Tapstand
B- Hand-dug well - uphill		• Well – uphill
C- Hand-dug well - downhill		• Well – downhill
D- Excreta disposal / sanitation		• Household latrines
E- Hygiene practice		• Hygiene practice
F - Vector control		• Vector control
G- Solid waste management		• Disposal sites
H- Drainage	1	• Domestic wastewater drainage
	2	• Stormwater drainage

2. **Identify hazards and hazard characteristics**
Hazards need to be identified. Some hazards are complex, and specialist support may be needed to obtain a reliable overview of hazards and their characteristics in a given location. Hazards and hazard characteristics may also change because of climate change or changes in demographics or environment. It is therefore important to consider possible changes in hazards and their characteristics.

For La Esperanza, interviews, focus groups, historical profile and direct observation pointed to two main hazards: landslide and flooding.

A hazard assessment **form**[18] was then filled in for each of these hazards. This form documents information about the hazard. This worked example has been done only for one of the identified hazards (landslides), and is shown below. The part in green will be taken forward to subsequent forms.

HAZARD DESCRIPTION	LANDSLIDE
(list one hazard per form)	
History and frequency of hazard event	• Landslides have taken place as long as people can remember but over time landslides have become more severe and more frequent. • This is probably related to the clearance of the forest. • In the catchment basin of La Esperanza, landslides occur on a yearly basis. • Heavy landslides that damage livelihoods or infrastructure happen around once every three years.
Probability of hazard occurrence **Score:** **1. Rare (<1 per 500 years (yr))** **2. Unlikely (1 per 100 to 500 yr)** **3. Possible (1 per 20 to 100 yr)** **4. Likely (1 per 5 to 20 yr)** **5. Almost certain (>1 per 5 yr)**	• 5: Almost certain (>1 event per 5 years)
Warning signs and speed of onset	**Medium-term signs:** • Deforestation of areas with high gradients, signs of erosion **Short-term signs:** • Intense rains, heavy erosion, subsidence in terrain. Speed of onset: seconds to days.
Location(s) affected	• Areas with a high gradient and areas below these • Mostly agricultural areas or zones without forest cover. • Inclined areas above riverbeds, areas that suffer from erosion. • See hazard map.

18 Adapted from: Venton, P.; Hansford, B. (2006) Reducing risk of disaster in our communities.

HAZARD DESCRIPTION	LANDSLIDE
Severity and impact	• There has not been any loss of life up to now. Dwellings and household plots have not yet been affected, but exposure is increasing. • The damage done to agricultural land is usually permanent as the landslide removes the topsoil and exposes rocky soil that cannot be cultivated. • Impact on individual households can be severe as livelihoods are destroyed through the loss of crops, agricultural land and livestock. Possibly 1/4 of all households have been affected by landslides in the past. As it is the most vulnerable who are left with the areas most at risk, it is especially these households that are hit.
Timing/ seasonality	• Most landslides occur in the rainy season, but there have also been smaller landslides in the dry season.
Duration	• The actual landslides in the catchment area of La Esperanza usually last for seconds to minutes, follow-up landslides have occurred.
Projection for the future	• With increasing deforestation the risk of landslides in the area is increasing. • With deforested areas creeping closer to the village, the risk of landslides affecting household plots, and resulting in death and injury will increase. • It is expected that with climate change the intensity of the rains will become stronger, which will further increase the future risk of landslides.
Attitude of society	• In focus group discussions landslides are recognised as a problem; especially poorer households practicing agriculture on small plots (the poor are usually left with terrains with higher gradients) recognise landslides as a serious threat to their livelihood. • To some extent people have come to see landslides as a fact of life and accept the risk. If solutions could be brought they would probably be well received though.

The hazard map of 'La Esperanza' is presented in the **figure below.**

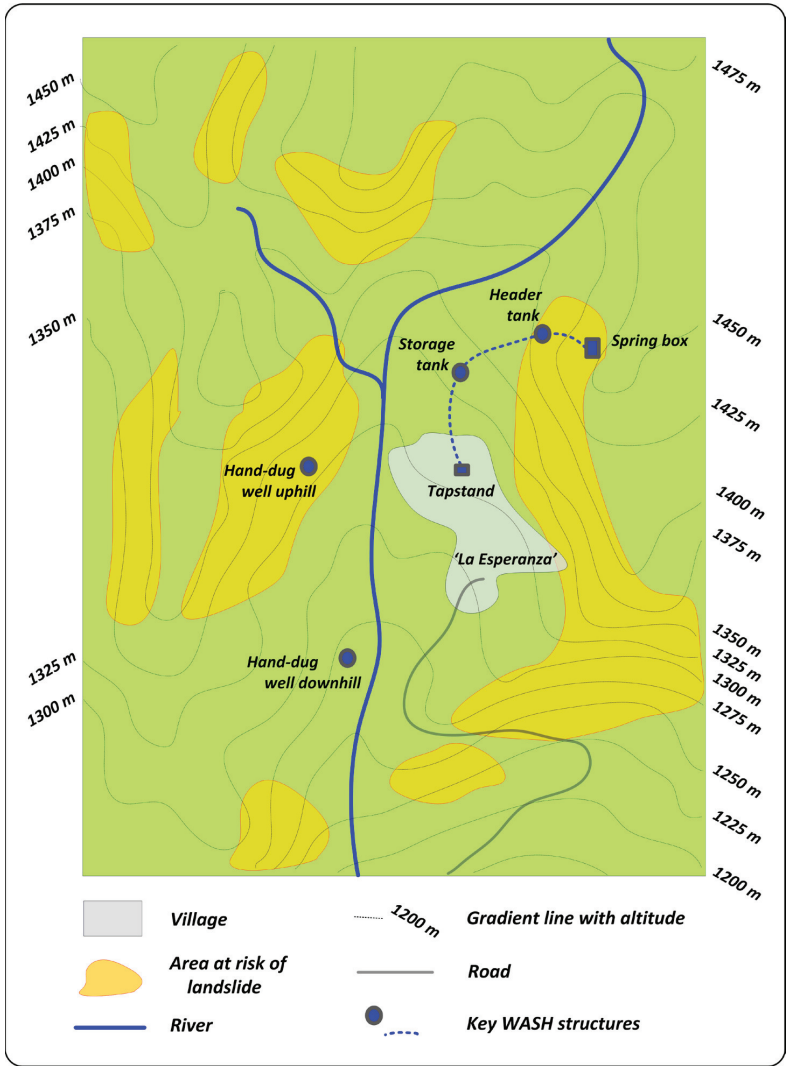


Figure 11: Hazard map of 'La Esperanza'

Information about the hazard is then used to asses possible impact on the WASH services or functional units identified in step 1. The parts in green in the form will be taken forward to subsequent forms.

HAZARD	LANDSLIDE	HAZARD EXPOSURE
WASH service or functional unit	Description of hazard's effect	Score: 0. none; 1. negligible; 2.low; 3. medium; 4. high; 5. very high
A1. Spring box	The spring box is in sloping terrain and a landslide could easily destroy it, with a risk that the spring is entirely lost.	5. very high
A2. Pipe section spring box to header tank	The pipe section is in sloping terrain and a landslide could easily destroy it.	5. very high
A3. Header tank	The header tank is in sloping terrain, a landslide could easily destroy it.	4. high
A4. Pipe section header tank to storage tank	The pipe section runs through terrain that is very much at risk of landslide.	5. very high
A5. Storage tank	The storage tank is currently placed in an area that is at low risk of landslide. Erosion, agricultural practices and other landslides may increase the risk over time.	3. medium
A6. Pipe section storage tank to tapstand	The pipe section is currently running through a zone that is at low risk of landslide, but the risk may increase over time with advancing deforestation.	2. low
A7. Tapstand	The tapstand is in the centre of the village and not exposed to landslide risk; it is not expected that this will change.	2. low
B. Well – uphill	The well is in terrain that is at medium risk of landslide; a landslide might result in a complete loss of the well.	3. medium
C. Well – downhill	The well is in terrain that is at low risk of landslide; though this may change over time.	2. low
D. Latrines	The majority of the latrines are placed in terrain that is at low risk of landslide. Some however are more exposed and might in the future be lost to landslide. However, the overall impact of the loss of some latrines on the community would probably be limited.	2. low
E. Hygiene practice	Hygiene practice is dependent on a good water supply; since the water supply is at high risk of landslide, hygiene practice is as well.	4. high
F. Vector control	Vector-borne infections and vectors are not an issue and no vector control is taking place; vector control is not affected by landslide.	Not applicable
G. Solid waste management disposal sites	The impact of landslide on solid waste management would be limited; some of the informal waste disposal sites might be lost, but people would probably continue to use the same area for waste disposal.	2. low
H1. Domestic wastewater drainage	Landslides would not affect drainage systems of domestic wastewater and drainage around the tapstand.	2. low
H2. Stormwater drainage	A landslide might cause the blockage of a passage for stormwater resulting in small-scale flooding.	3. medium

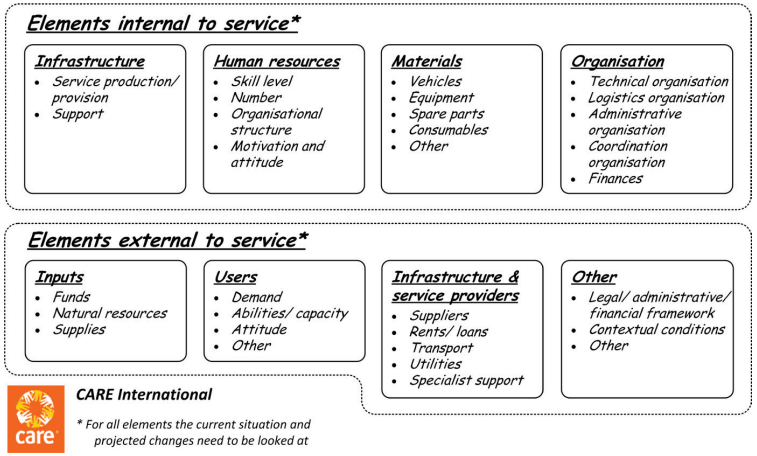
3

3 and 4. Identify and categorize vulnerabilities and capacities

With the main hazard risks known, the vulnerabilities of the services and the capacities present in society to deal with the effects of a hazard event have to be identified.

The proper functioning of WASH services can depend on many elements – these are illustrated using the WASH Service Performance Framework (see the overview below for more details, see Annex 2: The WASH Service Performance Framework for more detail).This framework is used to assess a WASH service and can be adapted to any WASH service (e.g. rural or urban, water or other WASH service such as vector control, emergency or development interventions).

WASH Service Performance Framework (summary overview)



With some exceptions, disasters can potentially damage, or affect, virtually all of these elements. This may lead to service breakdown or degradation, which may result in a reduced service level, and potentially a secondary disaster. Therefore the vulnerability and capacity of each element needs to be investigated. This only needs to be done for individual WASH systems that would suffer from medium or strong shock (the parts in green from the previous form in step 1). Exceptions to this would be if particular systems were critical to households or were very complex.

In this example, four of the WASH systems from step 1 would be assessed against landslides:

A1 to A5: Gravity-fed water distribution system
B. Well - uphill
E. Hygiene practice
H2. Stormwater drainage

The vulnerability of each WASH system and capacity present is investigated and recorded for each of the affected WASH components listed above. One form should be completed per hazard – the example below is for landslide.

HAZARD **LANDSLIDE**

Score: 0. negligible; 1.low; 2. medium; 3. high; 4. very high

WASH SERVICE OR FUNCTIONAL UNIT	VULNERABILITIES TOWARDS HAZARD	Level of vulnerability	CAPACITIES TOWARDS HAZARD	Level of capacity
A1. Spring box A2. Pipe section spring box to header tank A3. Header tank A4. Pipe section header tank to storage tank A5. Storage tank	**Infrastructure** • Location of parts of the system in landslide-prone areas • Low level of protection of the system against landslides • The system does not easily allow mitigation measures for landslides • Landslide in spring eye area might result in complete loss of spring • The system is interlinked; if one element breaks down the whole system is affected, no redundancy is built in the system **Human resources** • Committee members are not representative of the community • Low technical and organisational skill level of the water committee • Committee members often absent **Materials** • No tools present • No spare parts present • No construction materials present	4. very high	**Infrastructure** • None **Human resources** • Water committee for system exists • Other members in community with relevant skills are present (e.g. construction workers) • Technical skills needed to repair landslide damage are relatively basic (except for damage to spring catchment) • Expressed interest of community members to get involved in repairing and maintaining the water supply system **Materials** • Relatively easy to protect materials from landslides • System does not need any consumables • Prices of materials are manageable with normal fee system if fees would be paid	1. low while several points were identified under capacity, these were often more a potential that could be built upon than a real capacity as present

HAZARD **LANDSLIDE**

Score: 0. negligible; 1.low; 2. medium; 3. high; 4. very high

WASH SERVICE OR FUNCTIONAL UNIT	VULNERABILITIES TOWARDS HAZARD	Level of vulnerability	CAPACITIES TOWARDS HAZARD	Level of capacity
	Organisation • No EPP in place to deal with landslide event • No systematic external support for committee or community in case of disaster event • No clear system for organisation of committee • No transparency of committee functioning **Inputs** • Damage by landslide can require many inputs for reconstruction • Few funds currently present for maintenance • No effective system in place for fee collection **Users** • Users feel little ownership of the system • Low level of trust of community towards committee • Livelihoods of several households might be affected reducing the capacity and willingness to pay **Infrastructure & service providers** • Not applicable as there are virtually no external actors **Other** • Perceived nepotism of committee members		• All materials needed (i.e. HDPE pipe, valves, reservoirs, fittings, construction materials) can be found in Bolivar **Organisation** • Adequate schooling level of committee members **Inputs** • System normally has low need for external inputs **Users** • A relatively strong social cohesion is present • Perceived importance of water supply system • Capacity of community members to pay fee is largely present **Infrastructure & service providers** • Not applicable as there are virtually no external actors needed **Other** • Church can provide support with construction materials and spares for minor repairs	
B. Well – uphill	**Infrastructure** ... **Human resources** ... **Materials** **Organisation** **Inputs** **Users** **Infrastructure & service providers** **Other**	3. high	**Infrastructure** ... **Human resources** ... **Materials** **Organisation** **Inputs** **Users** **Infrastructure & service providers** **Other**	3. high
E. Hygiene practice	...	4. very high	...	2. medium
H2. Stormwater drainage	...	2. medium	...	1. low

The recovery phase may present opportunities for change that may not be there in a stable situation. It is therefore important to identify the most important 'main pressures' and 'root causes' of vulnerabilities and assess whether opportunities to address these are present. Examples of such opportunities would be empowering women by the development of female task forces or increase political support for specific issues by lobbying activities.

5, 6 and 7. Define potential impact on WASH services and prioritize action

Using a scoring system for intensity, vulnerability and capacity, it is possible to assess the potential impact of the hazard on every service or unit. The formula used for this is shown below.

$$\text{Potential impact on WASH system/ unit} = \frac{\text{Hazard exposure x Vulnerability}}{\text{Capacity}}$$

The figure obtained gives a measure for the potential impact a hazard event would have on a particular WASH system or unit.

By multiplying the potential impact on a WASH system or unit by the probability of the hazard occurring, a measure of the priority of a specific system or unit is obtained.

$$\text{Measure of priority} = \text{Potential impact x Probability of occurrence}$$

The form in which this information is introduced is shown below. Again, this form only needs to be completed for individual WASH systems or functional units that would suffer from medium or strong impact. Parts in green in the form will be taken forward to the subsequent form.

HAZARD	LANDSLIDE				
PROBABILITY OF OCCURRENCE	5: ALMOST CERTAIN (>1 EVENT PER 5 YEARS)			(exposure x vulnerability/capacity)	(potential impact x probability)
WASH service or unit	Hazard exposure	Level of vulnerability	Level of capacity	Potential impact	Measure of priority for services
A1. Spring box	5. very high	4. very high	1. low	5 x 4 / 1 = 20	20 x 5 = 100
A2. Pipe section spring box to header tank	5. very high			5 x 4 / 1 = 20	20 x 5 = 100
A3. Header tank	4. high			4 x 4 / 1 = 16	16 x 5 = 80
A4. Pipe section header tank to storage tank	5. very high			5 x 4 / 1 = 20	20 x 5 = 100
A5. Storage tank	3. medium			3 x 4 / 1 = 12	12 x 5 = 60
B. Well – uphill	3. medium	3. high	3. high	3 x 3 / 3 = 3	3 x 5 = 15
E. Hygiene practice	4. high	4. very high	2. medium	4 x 4 / 2 = 8	8 x 5 = 40
H2. Stormwater drainage	3. medium	2. medium	1. low	3 x 2 / 1 = 6	6 x 5 = 30

The measure of priority for services is not an absolute figure, and only gives an indication of what services/ units may need attention. The measure of priority doesn't include the preferences stakeholders give to specific systems or the importance of the service for the community. This will be looked at in the next phase.

8. Action planning

In this example, the situation is considered to be worthy of warranting a project, and a proposal is made for a public health intervention.

The decision on whether mitigation/ preparedness measures will be developed will depend on the measure of priority for services listed above, on the preference of users, and on the importance of the services to society (e.g. for public health or food security), and on the technical, financial, and administrative feasibility. Specific measures that are considered feasible, effective and efficient are listed in the summary form below. Again, one form should be completed per hazard. Examples of mitigation and preparedness measures are listed in Annex 3: Mitigation and preparedness measures for WASH systems.

The example below shows the mitigation measures that will be taken for WASH services that are at risk of landslide and which are a priority for action.

HAZARD **LANDSLIDE**

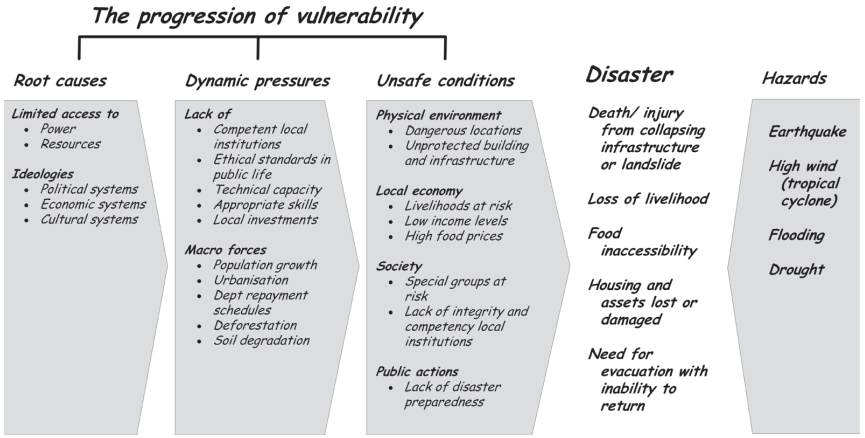
WASH service or functional unit	Measure priority services	Importance well-being community	Community preference	Decision for action	Mitigation/ preparedness measures
A1. Spring box	100	High	High	Yes	•Reforestation of areas at risk •Improve land management •Bridging pipe over areas at risk •Protection of pipe where bridging not feasible •Building local capacity to repair / maintain system (skills, tools, materials)
A2. Pipe section spring box to header tank	100			Yes	
A3. Header tank	80			Yes	
A4. Pipe section header tank to storage tank	100			Yes	
A5. Storage tank	60			Yes	
B. Well – uphill	15	Low	low	No	•Securing of water supply •Hygiene promotion
E. Hygiene practice	40	High	Medium	Yes	
H2. Stormwater drainage	30	Medium	Low	No	

A project is planned based on these elements; below a compact version of how the logical framework for this project could look. Parts specific to reducing disaster risk are in black.

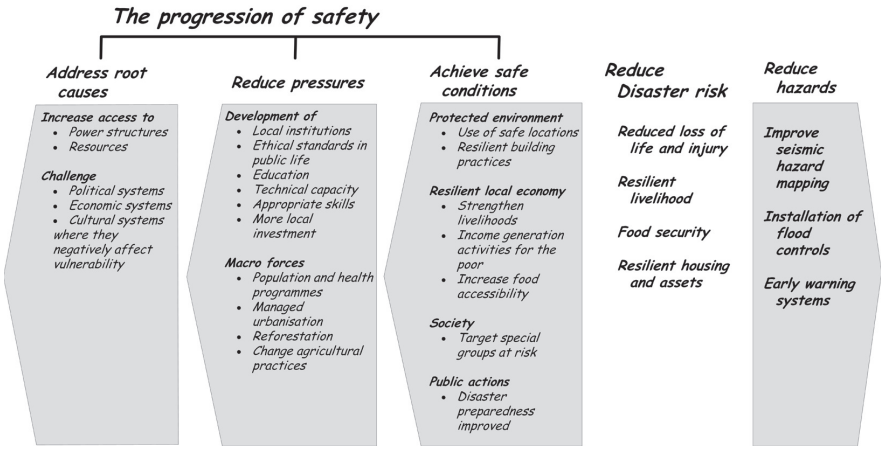
	INTERVENTION LOGIC	OBJECTIVELY VERIFIABLE INDICATORS	SOURCES OF VERIFICATION	RISKS AND ASSUMPTIONS
OVERALL OBJECTIVE	TO IMPROVE, IN A SUSTAINABLE MANNER, HEALTH AND WELL-BEING OF VULNERABLE HOUSEHOLDS IN THE PROVINCE OF EL PROGRESO			
Specific Objective	To reduce the risk of transmission of faecal-oral infections in the community of La Esperanza	**By the end of the project:** • 95% of households (HH) have a sustainable and resilient year-round supply of water providing 20 l/p/d and with a water collection time of maximum 10 minutes. • hygiene practice at HH level will have improved (based on handwashing practice and presence of faeces on HH plot) has gone from 40% to 90%. • 95% of inhabitants use improved, safe and secure sanitation facilities, up from 45% as identified in baseline survey.	• Baseline survey • Survey • Ex-post evaluation survey	• Stable local socio-economic conditions • …
Expected results	1. By month 12 in the project a sustainable, resilient, and adequate community-managed water supply system is operational 2. Hygiene practice significantly improved in La Esperanza by the end of the project. 3. By the end of the project, 95% of the inhabitants of La Esperanza are using improved safe and secure sanitation facilities.	• Sufficient revenue generated to cover running costs of water supply system and HP team plus 5% margin • Safety of structures (based on location, materials used, installation methods). • Respect of emergency prepared-ness plan (EPP) guidance in simulation. • Water supply system and sanitation facilities are conform national standards • One sustainable hygiene promotion (HP) 4-person team established. • Participant feedback on perception of security on using systems	• Baseline survey • Report simulation exercise • Community records • National standards • Ex-post evaluation survey	• Continued public health support of Ministry of Health • Food security remains stable • …
Activities	**1.1** Rehabilitate the water supply system using resilient installation methods and materials and for as much as possible, safe locations. **1.2** Install 5 public water points in accessible, safe and secure locations. **1.3** Strengthen the water committee on management capacity and ensure there is redundancy in the committee. **1.4** Work with water committee on a cost recovery and system management system. **1.5** Set up a damage assessment and repair unit with water committee with system for access to tools and spares, ensuring redundancy is built in system. **1.6** Prepare an EPP for community that includes strategies for maintaining access to adequate water in case of hazard event. **2.1** Establishment and training of HP team representative of community and consisting of vulnerable community members; the team will have built in redundancy. **2.2** Set up income generating activities for the HP team (e.g. soap-making), linking financial management to water committee. **2.3** Linking the HP team to Ministry of Health (MoH). **2.4** Building capacity of MoH. **2.5** Hygiene promotion activities in the community by the HP team. **2.6** Prepare approach for EPP on how to maintain good hygiene practices in case of hazard event. **3.1** Awareness raising activities on sanitation by HP team. **3.2** Community-managed construction of resilient latrines using locally available building materials. **3.3** Prepare approach for EPP on how to deal with excreta in community in case of hazard event.			

ANNEX 1 THE PRESSURE AND RELEASE (PAR) MODEL

A model used to analyse and present disaster risk is the 'Pressure And Release' (PAR) model. This model makes visible the factors that lead to disaster risk. Below is an example of a PAR model showing the progression of vulnerability, going from the unsafe conditions to the root causes of **vulnerability** [19].

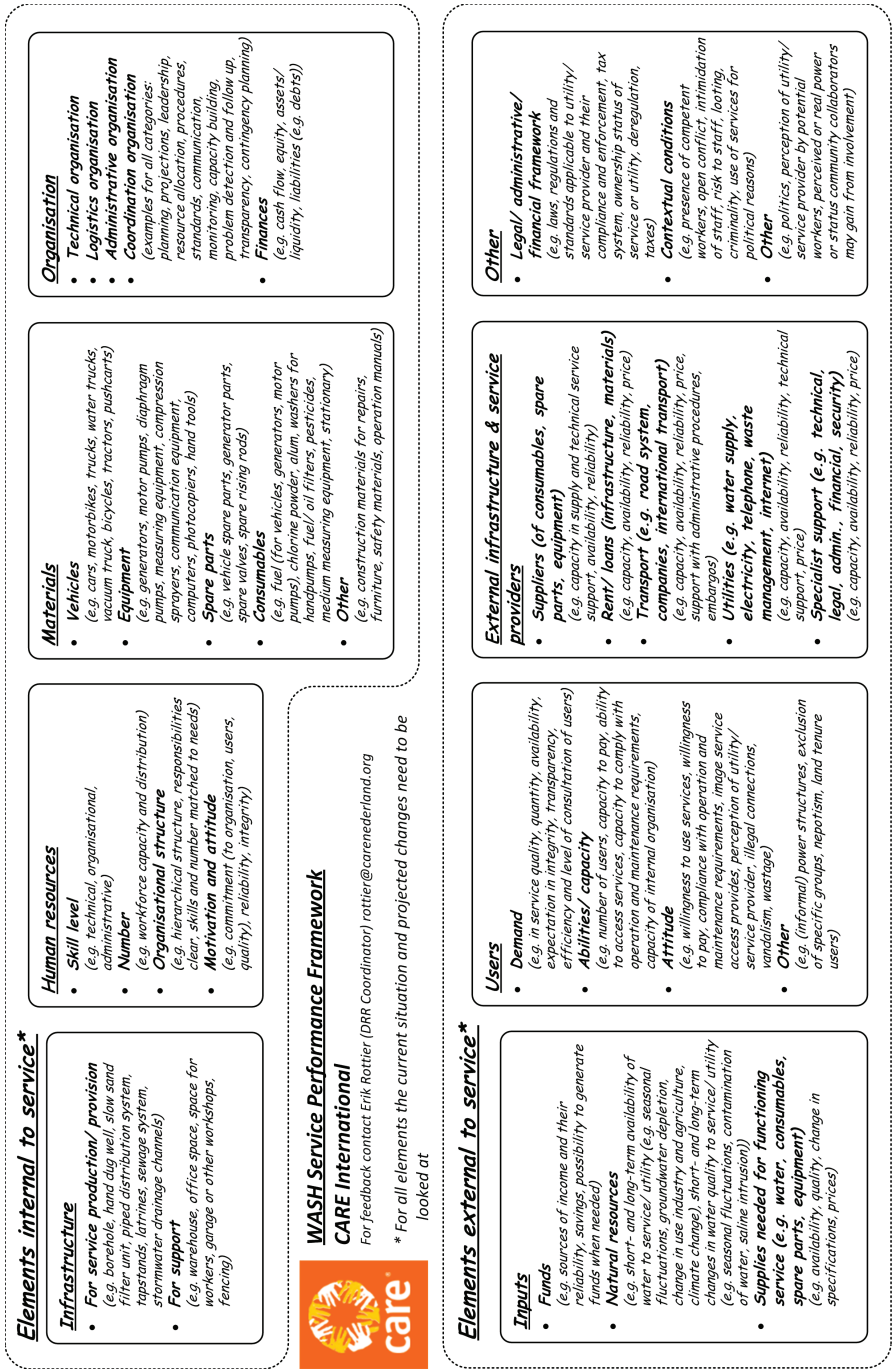


By inverting the model and creating a 'progression of safety' it is possible to visualise the actions would be necessary to reduce disaster risk in a society. Below the presents the PAR model showing the progression of **safety** [20].



19 Adapted from http://www.maf.govt.nz/mafnet/rural-nz/emergency-management/snow/farm-response-to-2006-canterbury-snow/page-06.htm
20 Adapted from http://www.maf.govt.nz/mafnet/rural-nz/emergency-management/snow/farm-response-to-2006-canterbury-snow/page-06.htm

ANNEX 2 THE WASH SERVICE PERFORMANCE FRAMEWORK



ANNEX 3 MITIGATION AND PREPAREDNESS MEASURES FOR WASH SYSTEMS[21]

Resilience of WASH services relates to protecting structures from the impact of hazard events and ensuring that service levels can be maintained.

Disaster risk of WASH systems can be reduced by choosing the most appropriate technology for a given risk context; some examples

- Local decentralized systems with higher autonomy over interdependent centralised systems (e.g. household latrines over small-bore sewage system; borehole with solar pumping system over pumping system powered by local power grid).
- More resilient structures over less resilient systems (e.g. looped network distribution system over branched distribution systems, more flexible ferrocement reservoirs over rigid brick reservoirs; flexible PE pipes over rigid cast iron pipes).
- Structures that will remain (partly) useable even after damage over systems that will become useless (e.g. hand dug well with access holes in cover slab instead of borehole).
- Preference for systems that can be repaired/ maintained at local level (e.g. if tractors are used locally; using tractors with trailers for transport of solid waste over imported compactor trucks).

Once the most appropriate technology is chosen, adequate standards have to be adhered to in setting up the system. Some examples

- Design standards: e.g. drainage channels around structures to avoid damage by stormwater; depth of wells to ensure water availability in dry periods.
- Standards in materials used: e.g. use of quality construction materials, use of materials with the proper features.
- Standards in workmanship: e.g. proper preparation and curing of concrete, correct jointing of pipes, proper compaction of fill.

Over time systems degrade and they will have to be maintained to uphold the level of resilience towards hazard events.

On integrating DRR in WASH; if in doubt: get specialist advice!

21 Adapted from references R3, R4, R5, R6, R31, R33, R34, R35, R36, R38

HAZARD: EARTHQUAKE

(SHAKING AND DISPLACEMENT OF THE GROUND)

Causes and risk factors

- Tectonic activity
- Powerful volcanic eruption

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure

- Location/ condition: identify and map risk areas; if possible, avoid known fault zones; build on consolidated deposits, avoid unconsolidated soils with (potential) high water content that may show liquefaction; install structures on soils with adequate load-bearing capacity (bear in mind that capacity reduces if the humidity of the soil increases); choose an accessible location; relocate services that are at risk of earthquake or its effects (e.g. landslide, liquefaction)
- Use structures and materials that have a higher resistance against the effects of earthquake: e.g. steel reservoirs generally support effects of earthquakes better than concrete reservoirs; choose flexible pipe materials (e.g. PE, steel, PVC) over rigid materials (e.g. concrete, cast iron); use flexible connections between components; heavy structures should be built on concrete slabs built in one piece; brace and attach structures properly; use earthquake resistant designs; steel-bodied pumps are preferable over pumps with a body of cast-iron; submersible pumps are often more resistant than surface-mounted pumps; install protection against fluctuations in voltage for larger electrical motors; use proper screens instead of slotted pipes in boreholes
- Quality of raw water can be affected by the effects of an earthquake, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Construct/ install so as to increase resistance against earthquake: e.g. ensure dams are able to resist earthquake; build covers of reservoirs and tanks in resistant materials; spring catchment structures should capture all water produced; reinforcement of wells; install asphaltic seals where pipes enter concrete structures (e.g. reservoirs); ensure there is space for movement of components (e.g. connections between reservoirs, openings where pipes pass walls); install seismic isolation bearings; place baffle plates in reservoirs, diagonal bracing of raised reservoirs; construct light yet earthquake-resistant structures; make round pits for latrines to reduce risk of collapse; adequately line latrine pits
- Liquefaction of saturated unconsolidated soils can result in pipes and heavy structures losing their support and collapsing, ensure proper support of structures; empty pipes, chambers and reservoirs can be pushed upward through floatation, when possible try to avoid entirely emptying these structures, concrete can be added to weight down structures to avoid flotation; replace soils that can not be compacted with soils that can be adequately compacted; injection techniques may be used to consolidate the soil; drainage can reduce the moisture content of the soil; install structures in consolidated layers below unconsolidated ones; compaction of soil; drill or drive piles to ensure adequate support

Materials

- Brace and attach materials properly

HAZARD: TSUNAMI

(WAVES CAUSED BY A RAPID DISPLACEMENT OF WATER)

Causes and risk factors

- Earthquake
- Powerful volcanic eruption
- Large mass movement (e.g. landslide, rockfall)
- Impact of meteorite

Combine with Generic mitigation and preparedness measures on page 65.

Hazard specific mitigation measures

Infrastructure

- Location/ condition: identify and map risk areas; avoid areas close to low-lying coastlines; mangrove forests, coral reefs, rocks can reduce the impact of large waves; avoid river banks close to the coast; install structures on soils with adequate load-bearing capacity (consider that capacity reduces if humidity increases); choose an accessible location; relocate services that are at risk of tsunami
- Use materials that cope better with the effects of a tsunami: e.g. where relevant choose flexible materials (e.g. PE, steel, PVC pipes; steel reservoirs) over rigid materials (e.g. concrete, cast iron pipes; brick reservoirs); use flexible connections between components; use high strength quality components; submersible pumps are often more resistant than surface-mounted pumps
- Construct/ install to increase resilience to a tsunami: e.g. build covers of wells, reservoirs, tanks and visit chambers in resistant materials; close wells, reservoirs, tanks and visit chambers to exclude salt water; reinforcement of wells; adequately reinforce and brace raised reservoirs; anchoring and supporting of pipes installed close to waterways; ensure the system can be cleaned out in case of contamination; repair leaks, maintain pressure 24h/24 in water distributions systems to avoid entrance of salt water in the system; make round pits for latrines to reduce risk of collapse; adequately line latrine pits; in unconsolidated soils, install a slab around the latrine pit

Inputs

- Water quality and availability (both of raw water and at the level of users) may change when a tsunami occurs: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability and quality (both of raw water and at the level of users) may be needed

HAZARD: VOLCANIC ERUPTION

(VOLCANIC ACTIVITY CAUSING ROCK FALL, ASH FALL, LAVA STREAMS AND RELEASE OF GAS)

Causes and risk factors

- Tectonic processes

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure

- Location/ condition: identify and map risk areas; if possible avoid areas at risk close to potentially active volcanoes; avoid areas that have been, or may become channels for lava, mudflows or landslides; install structures on soils with adequate load-bearing capacity (consider that capacity reduces if humidity in soil increases); choose an accessible location; relocate services that are at risk of volcanic eruption or its effects (e.g. ash rains, mudflows, lava flow, fire)
- Quality of raw water can be affected by the effects of a volcanic eruption, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Construct/ install to better resist the effects of volcanic eruption: e.g. build covers of wells, reservoirs, tanks and visit chambers in resistant materials able to resist to ash deposition; close wells, reservoirs, tanks and visit chambers adequately to exclude ash; construct protective walls and underground river passages for pipes; install mechanisms to exclude ash from drainage systems; ensure system can be cleaned out in case of entry of ash in system; use high strength quality components

Inputs

- Water quality and availability (both of raw water and at the level of users) may change following volcanic activity: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability and quality (both of raw water and at the level of users) may be needed

HAZARD: MASS MOVEMENT (I.E. LANDSLIDE, MUDFLOW, ROCKFALL, AVALANCHE...)

(SLOW TO RAPID MOVEMENT OF SOIL OR ROCK BY GRAVITY)

Causes and risk factors

- Topography
- Erosion
- Weathering of soil
- Loading of slope
- Deforestation or change of vegetation
- Intense rainfall
- Prolonged rains
- Change in ground water
- Rapid snow melt
- Thawing
- Excavation/ mining/ quarrying
- Water leakage
- Geological causes
- Earthquake
- Volcanic eruption

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure

- Location/ condition: identify and map risk areas; avoid spots in unconsolidated soils in inclined terrain, or points below these; areas below deforested zones are at risk (e.g. because of deforestation or fire); avoid areas close to natural drainage channels; Install structures on soils with adequate load-bearing capacity; avoid zones below inclined soils with a load (e.g. buildings) that might exceed their load-bearing capacity; choose an accessible location; relocate services that are at risk of mass movement
- Use materials that resist to some extent the effects of mass movements: e.g. choose resistant pipe materials (e.g. GI pipe); in some places flexible piping material (e.g. PE pipe) may be more adequate; use high strength quality components
- Construct/ install so as to better resist the effects of landslide, rockfall or mudflow: e.g. bridge pipes over zones at risk, alternatively lay pipes in solid rock (e.g. in areas at risk of rockfall pipes should be installed at least 0.6 m below the surface up to 1.2 m); if it is impossible to dig down pipes in an area at risk, incorporate the pipe in a wall and fill uphill of the wall to form a terrace; where displacement is very slow, flexible pipes may be placed in waves; install pipe anchors in solid soil close to areas at risk; proper backfilling and compacting of trenches; remove rocks that might be a risk for structures
- Consolidate areas at risk: e.g. landslides occur more easily in areas where the vegetation has been removed; avoid deforestation, where relevant and possible, do reforestation; build retention structures like retention walls or gabion structures to consolidate the soil; terracing
- Landslide, rockfall or mudflow can be a large risk to artificial reservoirs; in areas where mass movements could be a risk, obtain specialist advice on existing reservoirs or if a new reservoir is to be made. Systems to minimise the risks of blockage of intakes and overflows should also be looked at.

Inputs

- Quality of raw water can be affected by the effects of a landslide, rockfall, mudslide or avalanche, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water.

HAZARD: SUBSIDENCE

(LOWERING OF THE EARTHS' SURFACE IN RELATION TO A DATUM)

Causes and risk factors

- Geological processes
- Earthquake
- Tsunami
- Natural gas extraction
- Groundwater extraction
- Seasonal and biological processes

Combine with Generic mitigation and preparedness measures on page 65.

Hazard specific mitigation measures

Infrastructure

- Location/ condition: identify and map risk areas; if possible, avoid areas where effects of subsidence are most distinct; install structures on soils with adequate load-bearing capacity (consider that capacity reduces if humidity increases); relocate services at risk
- Use materials that resist the effects of subsidence: e.g. flexible structures (e.g. steel reservoirs; PE, steel, and PVC pipes) will support the effects of subsidence better than do rigid structures (e.g. brick reservoirs; concrete and cast iron pipes); use high strength quality components
- Construct/ install so as to better resist the effects of subsidence: e.g. reinforcement of wells; install asphaltic seals where pipes enter concrete structures (e.g. reservoirs); subsidence may result in a modification of gradients in systems, this has to be considered in designs of gravity dependent systems (on-site sanitation may be more adequate than off-site sanitation); make round pits for latrines to reduce risk of collapse; adequately line latrine pits

Inputs

- Water availability may change when subsidence occurs: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability may be needed

HAZARD: GENERAL FLOOD/ FLASH FLOOD (ONE OF HAZARDS LINKED TO TROPICAL CYCLONE)

(GENERAL FLOOD: SLOWLY RISING WATER LEVELS CAUSED BY RAINFALL OR SNOWMELT; FLASH FLOOD: RAPIDLY RISING WATER LEVELS, CAUSED BY RAINFALL, DAM BURST...)

Causes and risk factors

- Prolonged rains
- Snowmelt
- Breach of dam/ outburst of glacial lake
- Topography
- Deforestation
- Poor stormwater drainage
- Poor solid waste management
- Urbanisation
- Poor water management
- Poor farming practices

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure

- Location/ condition: identify and map risk areas; avoid low-lying areas and natural drainage paths; unconsolidated soils that may erode, or soils that shrink-swell under the effect of water are a risk; avoid areas close to low-lying coastlines or river banks; avoid the outer bends of rivers as erosion is stronger here, inner bends and straight stretches are less at risk; avoid areas close to natural drainage channels; install structures on soils with adequate load-bearing capacity (capacity reduces if humidity increases); accessible location; relocate services that are at risk of flooding or its effects (e.g. high water levels, erosion, deposits of sediments, potentially destructive floating debris, soils that shrink-swell)
- Use materials that resist the effects of flooding and erosion: e.g. concrete structures with solid foundations; choose materials with high strength in areas that could be exposed to strong currents or floating debris; use high strength quality components
- Quality of raw water is likely to be affected by flooding, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Construct/ install so that structures resist the effects of flooding: e.g. bridge pipes over natural drainage channels; alternatively dig in pipes; install pipe anchors in solid soil close to areas at risk; build covers of wells, reservoirs, tanks and visit chambers; close wells, reservoirs, tanks and visit chambers adequately to exclude as much as possible flood water and sediments; reinforcement of wells; rise structures (e.g. well openings, entry/ exit points for pipes in wells, latrine) at least 0.3 metres above the maximum flood level, install electrical installations well above the maximum flood level; treat walls and structures to protect against flood water; repair leaks; maintain 24h/24 pressure in water distributions systems to avoid entrance of contaminated water and/or solids (silt, mud) in the system; ensure presence of proper sanitary seal in wells and boreholes; place intake structures where floating debris cannot affect it (e.g. by placing the intake in a channel placed laterally from the river); adequately reinforce and brace reservoirs and other structures; where there is a risk of floodwater backing up through sewerage systems, install sewer backflow valves; make round pits for latrines to reduce risk of collapse; adequately line latrine pits; in unconsolidated soils, install a slab around the latrine pit

HAZARD: GENERAL FLOOD/ FLASH FLOOD (ONE OF HAZARDS LINKED TO TROPICAL CYCLONE)

- Damage through erosion is a serious risk: examples of measures: construct adequate foundations; dig in pipes deep enough to avoid uncovering; protect structures from erosion through installation of drainage channels around them, lining or protecting channels through structures that dissipate energy or control erosion (e.g. check walls, dissipators, gabions, vegetation); build impermeable slabs around structures like wells; cover pipes with a concrete slab or place them in a concrete beam; ensure sediments are dealt with adequately through regular cleaning, settling basins; proper backfilling and compacting of trenches; build retention walls or gabion structures to consolidate the soil; terracing; ensure the capacity of the drainage structures are adequate; ensure properly dimensioned overflow structures for dams
- Erosion may change the course of rivers, potentially leading to loss of intake(s). If this were to happen a strategy must be present to deal with this
- Areas that are not covered with vegetation (e.g. deforested areas, urban areas) discharge more water, and discharge it more rapidly than areas with vegetation: where possible avoid deforestation, and where relevant and possible, reforest catchment basins
- Ensure that by discharging water rapidly and effectively in one area no problems are created in areas further downstream
- Empty pipes, chambers and reservoirs can be pushed upward through floatation, if this is a risk, avoid emptying these structures entirely

Inputs

- Water quality and availability (both of raw water and at the level of users) will change when flooding occurs: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability and quality (both of raw water and at the level of users) may be needed

HAZARD: STORM SURGE (ONE OF HAZARDS LINKED TO TROPICAL CYCLONE)

(SHORT-TERM RISE IN SEA LEVEL ABOVE NORMALLY EXPECTED TIDE)

Causes and risk factors

- Tropical cyclone
- Storm
- Form of coast line and seabed
- High tide

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

- See hazard specific mitigation measures mentioned under tsunami page 52

HAZARD: WIND STORM (ONE OF HAZARDS LINKED TO TROPICAL CYCLONE)

(WINDS WITH HIGH SPEEDS)

Causes and risk factors

- Climatological processes
- Weather processes

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

If storm surge is a risk, combine with hazard specific mitigation measures under tsunami page 52

Infrastructure

- Location/ condition: identify and map risk areas; for structures vulnerable to strong wind: avoid higher areas, ridges, flat terrain, open ground; where unavoidable, assess mitigation methods in areas at risk of collapsing poles, antennas, trees, flying roofing materials; accessible location
- Use materials that resist the effects of strong winds: e.g. concrete structures over wooden structures; use high strength quality components
- Quality of raw water can be affected by the effects of storms, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Construct/ install so as to better resist the effects of strong winds: e.g. build covers of reservoirs and tanks in resistant materials; diagonal bracing of raised reservoirs; anchoring structures that may take wind (e.g. steel reservoirs, poles); ensure roof structures are strong enough and rafters are attached properly to walls; avoid buildings with large unsupported spans; brace gables of roof; ensure roofing material is attached adequately; secure and reinforce doors; damage may come from wind or from flying debris, install storm shutters in front of openings and windows; where possible seal structures so wind cannot enter; remove debris and loose materials that may damage water pipes and other structures; ensure structures are well installed and anchored
- Reservoirs are most vulnerable when they are empty, keep reservoirs full during a storm (that includes water towers)

Materials

- Where necessary, ensure materials are adequately anchored

Inputs

- Water availability at user level may change when a wind storm occurs: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability and quality may be needed

Other

- Take care with elements that surround structures: trees or structures (e.g. antennas, power lines, towers) may fall over under the effect of strong winds or flying debris, trim or cut trees that might be a threat, anchor structures; loose materials may become dangerous projectiles, remove all non essential materials, attach or anchor or brace materials that cannot be removed

HAZARD: EXTREME TEMPERATURES - HIGH TEMPERATURES

(WINDS WITH HIGH SPEEDS)

Causes and risk factors

- Climatological processes
- Weather processes

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure

- Water demand will be higher; enough capacity of supply must be built in the system
- Construct/ install so as to better resist the effects of high temperatures: close wells, reservoirs, tanks and visit chambers adequately to exclude dust and minimise evaporation; use high strength quality components; ensure that buildings have a good circulation of air, install roof with double ceiling, with adequate ventilation between the two; high ceilings are preferable over low ceilings; install roof ventilators; insulate buildings; shade infrastructure where needed; painting structures in light colours reflects heat; install shade screens over openings; install ventilation in roofing structures; ensure heat produced by machinery is evacuated properly; work areas and materials that have to be handled should be in shaded areas; set up a system of rapid detection and repair of damage
- In dry conditions, concrete should be kept moist during curing

Materials

- The heat may affect materials and equipment: chemicals will usually degrade more rapidly in hot conditions, store in cooler areas; machinery may overheat, install fans to cool equipment; clean machinery if there is build-up of dust; sensitive materials and equipment may need air-conditioning

Inputs

- Water quality and availability (both of raw water and at the level of users) may change when a period of extreme heat occurs, reservoirs and river dry up or run low, and groundwater is not recharged: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability and quality (both of raw water and at the level of users) may be needed

HAZARD: EXTREME TEMPERATURES - LOW TEMPERATURES

Causes and risk factors

- Climatological processes
- Weather processes

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure

- Location/ condition: identify and map risk areas; where drifting snow could be an issue, try to locate structures so that they are exposed to wind and sun; place structures and installations where the risk of destruction by (moving) ice is reduced; install structures on soils with adequate load-bearing capacity (capacity reduces if humidity increases); accessible location
- Use materials and designs that resist the cold: e.g. MDPE and HDPE pipes are more resistant to freezing conditions than UPVC pipes; use of pre-insulated pipes; install pipe systems so water can remain in permanent circulation; in areas where population density is low and the risk of freezing conditions is high, decentralised systems may be more adequate than centralised systems; try to avoid dead ends in designing piped systems; use high strength quality components
- Quality of raw water may be affected by the effects of freezing temperatures, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Construct/ install so as to better resist the effects of extreme cold, ice expands and can crush components in systems: e.g. consider the weight and potential movements of snow and ice, underground reservoirs are less exposed than reservoirs placed on the surface; water masses in large reservoirs will freeze less quickly than small reservoirs; use submersible pumps over surface mounted pump; install pumps, exposed valves, pipes and reservoirs inside buildings or insulate them; place pipes deep enough to avoid frost; install purpose-made electric heating cables inside pipes; keep water flowing through recirculation or leaving some taps open; drain pipes when not in use; protect surface water intakes from (blocks of) ice; make round pits for latrines to reduce risk of collapse; adequately line latrine pits; build the roofing of structures so they will resist the weight of snow and ice; employ specialists and workers who are familiar with local conditions and experienced with working in, and setting up systems for, cold weather conditions

Human resources

- Protect staff from cold (cold may also be an issue above freezing-point): ensure that the spaces where people are at work are warm enough; install heating (consider the risks of fire and carbon monoxide poisoning); insulation of walls, floors and roofs; minimise draughts through openings; keep ceilings low; install small windows, protect with shutters or double glazing

Organisation

- Cold temperatures affect chemical and physical processes: longer contact times are needed for chlorination (and other disinfection methods) to be effective; because of higher viscosity of water head loss in treatment systems and pipes is higher compared to warmer conditions; natural and assisted sedimentation processes will be slower; pumping requires more energy

HAZARD: EXTREME TEMPERATURES - LOW TEMPERATURES

- Freezing conditions can make construction and maintenance works more challenging: e.g. curing concrete has to be protected from frost, painting should be done above freezing temperatures; frozen soil is more stable than thawed soil
- The risk of system failure is high in sub-zero conditions and alternatives to essential systems have to be in place (e.g. water trucking)

Inputs

- Water quality and availability (both of raw water and at the level of users) may change during a cold wave: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability and quality (both of raw water and at the level of users) may be needed

HAZARD: DROUGHT

(LONGER PERIOD OF TIME WITH BELOW AVERAGE AMOUNTS OF PRECIPITATION)

Causes and risk factors

- Climatological processes
- Weather processes

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure

- Location/ condition: choose locations for structures that reduce the impact of drought (e.g. place wells and boreholes in areas where groundwater level is relatively high); be careful in coastal areas and areas with saline aquifers, the interface between fresh and saline water may fluctuate resulting in a reduced fresh water supply; boreholes that are too deep, or that are over-pumped, may start yielding saline water, resulting in loss of the borehole; in humid zones avoid installing structures in areas with expansive soils; choose an accessible location
- Design systems so as to maximise water use efficiency: e.g. repair major leaks; effective leakage detection and repair system; build spring box with springs to reduce waste during times of low demand; install cattle troughs to minimise water loss at watering points; install drip irrigation systems instead of systems like furrow, border or sprinkler irrigation; introduce safe systems of reusing wastewater
- Quality of raw water is likely to be affected in drought conditions, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Construct/ install so as to better resist the effects of drought and minimise water loss: where dust is an issue, close wells, reservoirs, tanks and visit chambers adequately, this will to some extent also help in reducing evaporation; use quality components; repair and protect existing critical water points and ensure proper maintenance, especially of critical components like handpumps (e.g. through introduction of a payment system for water use and maintenance of point); build sedimentation traps to control siltation; yearly desilting of watering pans; excavation of water pans

HAZARD: DROUGHT

- Water demand might increase: where possible measures should be taken that increase storage capacity and yield: e.g. prepare watering pans; wells with larger diameter; installing lateral collection pipes in a well; install water saving measures; certain uses of water (e.g. industrial, irrigation) may have to be limited; water-borne sanitation systems (e.g. sewerage systems) are very wasteful of water and their use should be limited in drought-prone areas
- Reservoirs and rivers dry up or run low, and groundwater refill will be limited or absent. Measures that will increase storage capacity, recharge reservoirs/ aquifers, increase access to water or improve water management should be looked for: e.g. mapping of water sources and their state/ use; install new water sources after study of users needs; drill deeper boreholes; deepening of handdug wells; artificial groundwater recharge through for example the use of check dams, percolation ponds, channel systems, recharge pits; installation of sub-surface dams; make or prepare contingency water sources; improve water management systems; change of water availability may result in water distribution systems not being under pressure continuously, increasing the risk of contamination of the system. A system of monitoring of water quality must be present, and problems must be quickly eliminated
- The lack of water may result in a build-up of soil, debris and waste in stormwater drainage systems: where this is an issue, the system must regularly be cleaned out.
- Drought conditions may result in more dust, susceptible systems will have to be protected
- In dry conditions, concrete should be kept moist during curing

Organisation
- Strategic supplementing water supply (e.g. transporting water to cattle herders) may be justified

Inputs
- Water quality and availability (both of raw water and at the level of users) will change in drought, reservoirs and river dry up or run low, and groundwater is not recharged: scenarios for dealing with this adequately are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring water availability and quality (both of raw water and at the level of users) may be needed

Other
- If necessary, develop conflict mitigation strategies where conflict may arise over water access

HAZARD: FIRE

(UNCONTROLLED FIRE)

Causes and risk factors
- Weather conditions (high temperature, thunder)
- Presence of fuel
- Topography
- Human factors

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infrastructure
- Location/ condition: identify and map risk areas; avoid areas with high fuel loads; avoid zones close to human activity (e.g. industry) that heighten fire risk; the risk of wildfire is larger in canyons and on slopes; choose an accessible location
- Develop strategies to reduce the risk of fire damage: develop mitigation strategies to deal with high fuel loads around installations; create safety zones with minimal vegetation and flammable materials around structures (e.g. fire breaks, create a 'defensible space' with a clean zone and a reduced fuel zone); provide materials to detect and cope with small-scale fires (e.g. attributed water/ sand reservoirs with motor pumps, smoke detectors, fire extinguishers, fire blankets, protective clothing) and training in their use; store liquid gas containers in safe areas; protect electrical systems
- Use materials that resist fires: e.g. use non-flammable construction materials (e.g. brick, concrete), treat flammable materials with fire retardant chemicals, or use materials that are pre-treated with these; as roofs are particularly exposed ensure roofing materials are non flammable; use quality components
- Quality of water can be affected by fire and pollution of water used for quenching, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Construct/ install so as to control the effects of fire: e.g. build at a distance from sources of fuel; build covers of wells, reservoirs, tanks and visit chambers in resistant materials; close wells, reservoirs, tanks and visit chambers adequately to exclude ashes; ensure there are hydrants in urban areas

Inputs
- Large fires will increase water demand; this demand will have to be considered in the system design, if possible maintain pressure 24h/24 in water distributions systems to avoid entrance of pollution in the system and to ensure availability of water for quenching fires
- Large fires may result in a degradation of surface water quality: systems must be in place to detect and deal with this

HAZARD: EPIDEMIC

(INCREASE IN THE NUMBER OF CASES OF AN INFECTIOUS DISEASE ABOVE WHAT IS CONSIDERED NORMAL LEVEL)

Causes and risk factors

- Presence or introduction pathogen
- Environment favourable to transmission (e.g. presence pathogens/ vectors/ hosts, poor sanitation)
- Inadequate services (WASH, public health)
- Behaviour causing transmission
- High population density
- Population displacement
- Low resistance or immunity level in population

Hazard specific mitigation measures

Combine with Generic mitigation and preparedness measures on page 65.

Infection-specific measures

- Water-borne infections: maintain adequate quality of raw water; repair leaks; ensure adequate chlorination of drinking water; set up system of quality control and system of dealing with potential contamination; maintain pressure 24h/24 in water distributions system; educate users in proper handling and use of water
- Excreta-related infections: ensure that excreta cannot contaminate environment or come in contact with persons, animals or insects; set up system of quality control and system of dealing with potential issues; educate proper behaviour with respect to excreta
- Zoonosis (infections that can be transmitted from animal to human): where relevant, control of animal hosts (e.g. rats), educate in proper handling of animal hosts
- Schistosomiasis: ensure that users do not need to come in contact with surface water; educate in transmission route and prevention
- Water-washed infections: ensure adequate water availability; educate on personal hygiene
- Mosquito-borne infections: adequate drainage of wastewater (clean water Anopheles and Aedes mosquitoes; organically contaminated water Culex mosquitoes); management of solid waste (Aedes and Culex mosquitoes); avoid creating breeding sites in water supply systems (Anopheles and Aedes mosquitoes); educate in transmission route and prevention
- Louse-borne infections: ensure adequate water availability; educate on transmission route and prevention

Infrastructure

- Quality of water can be affected by epidemics, try to design the structure so there is capacity to deal with changes in water quality; try to have/ identify reliable alternative sources of water
- Avoid areas with an environment favourable to disease transmission

Human resources

- Build the capacity of staff and caretakers on the protection of public health

Inputs

- Water quality and environmental sanitation may become crucial in epidemics: scenarios for adequately dealing with changing requirements are needed; identify and prepare potential access/ use of alternative water sources; a system of monitoring WASH service level and quality may be needed

ANNEX 3

GENERIC MITIGATION AND PREPAREDNESS MEASURES

Generic mitigation measures

Combine with hazard specific mitigation measures and preparedness measures.

Infrastructure

- Ensure proper sanitary seals in wells and boreholes
- Design systems to facilitate repairs, build in redundancy: e.g. standardise components; set up a system of rapid detection of leaks or other issues and repair; install enough unions in GI pipe systems; install valves on both sides of parts at risk in the system; use looped network system over branched systems; install a generator as back-up for power grid

Human resources

- Protect staff from the potential effects of hazard event
- Build the capacity of staff and caretakers
- Ensure relevant information is available to staff (e.g. areas at risk, safety procedures, organisational procedures)
- Encourage a culture of cohesion, responsibility and focus on quality and results in the teams
- Ensure there is redundancy in staffing, workers should be able to fill in for each other if someone is not able to fulfil his/her responsibilities

Materials

- Use high strength, flexible, quality materials
- Standardisation of materials and equipment used
- Ensure storage facilities are able to withstand the hazardous event and that materials are stored safely
- Ensure storage and transport systems of chemicals (e.g. chlorine) do not result in risk of intoxication and/ or contamination; safety is an important criterion in the choice of materials (e.g. powdered chlorine products versus chlorine gas)
- Build safety margins in stock levels, transport capacity, spare equipment

Organisation

- Build redundancy in the organisation; ensure components in the organisation can fill in for each other
- Build autonomy in the organisation: ensure the organisation is set up so that teams are able to function with reasonable independence
- Push responsibility to the lowest level able to handle that responsibility, ensure proper monitoring and follow up, but give real responsibility to persons lower in the hierarchy. Ensure decisions on damage control, safety and security measures can be made easily and rapidly. Avoid 'the man with the key has gone' situations
- Build in security factors in the organisation so that capacity of key parts or functions of the organisation is adapted to the potential needs in case of emergency (e.g. logistics, communication). It is possible that external capacity has to be identified and negotiated
- Set up systems to ensure the most vulnerable have access to services

GENERIC MITIGATION AND PREPAREDNESS MEASURES

Generic preparedness measures

Inputs
- Identify and prepare alternative sources of water
- Set up systems of quality control and of dealing with potential contamination. Ensure protocols for changes in water quality and availability (both of raw water and at the level of users) are worked out, and a strategy to deal with these in practice is present

Users
- Involve users in service provision

External infrastructure and service providers
- Ensure agreements and contracts on borrowed, loaned, rented or subcontracted infrastructure, equipment and services with regards to potential hazard events are in order; attention points are liability (both to society and with regard to the object in use). Responsibility of repair or replacement, continuation of subcontracted service, security of continuation of agreement

Other
- Lobby for support in mitigation activities in society and for the WASH services
- Try to link with other ongoing mitigation initiatives

Combine with hazard specific and generic mitigation measures.

Infrastructure
- Prepare infrastructure for potential hazard event or secondary effects: e.g. monitor condition, and repair and maintain infrastructure; install drainage channels; protect pipes that are exposed; when event is imminent, take emergency protection measures (weigh down roofs and fill reservoirs to stabilise against wind, shutter openings); prepare for changes in needs (e.g. prepare landfill site so large quantities of debris can be disposed of rapidly; structures to deal with changes in water quality)
- Prepare for damage in infrastructure: ensure local capacity for repair and operation: (e.g. train community members in repair, operation and monitoring; preposition generator with fuel stockpile at external stations; preposition materials and tools); set up system for early detection of issues (e.g. bacteriological testing of water at distribution points). Based on damages expected, prepare strategies and systems for rapid recovery of critical service levels, and reconstruction taking into account the need to increase resilience

Human resources
- Prepare for human resource issues following a hazard event: ensure more people in the community have the skills needed to adequately operate and maintain structures; prepare for changes in staffing levels and/ or reduced access (e.g. prepare systems of operation with reduced staff levels; find alternative means of (safe) transport for staff (e.g. agreement with owner of motorised boat to transport staff)); ensure staff has the knowledge and skills needed for dealing with the effects of a hazard event, both on a professional as a personal level (e.g. safety and security

ANNEX 3

GENERIC MITIGATION AND PREPAREDNESS MEASURES

issues); where relevant, ensure staff can remain in place and be autonomous, possibly with family (e.g. prepare safe sleeping spaces, preposition food, water, fuel, safe heating equipment, kitchen materials, matches)
- Where relevant, form intervention teams that can take on specific tasks: e.g. first aid; search and rescue; fire fighting; containment of dangerous waste; damage assessment; rapid repair; monitoring of quality. Teams have to be trained and supplied with adequate materials and equipment
- If relevant, set up systems for support of staff (e.g. mental health support)
- Develop simulations of emergencies and exercises with teams and communities so as to build up experience and skills and test systems

Materials
- Prepare vehicle park for event: e.g. ensure vehicles are in order and equipped; bring non-essential vehicles to safety; stock fuel and strategically place fuel stores
- Prepare for additional need in transport: vehicles may be damaged/ lost; additional demands may need more capacity or different capacity (e.g. need for extra transport capacity to deal with repairs and controls, need to transport large quantities of debris after earthquake or flooding, need for water trucks). Try to negotiate additional capacity beforehand
- Prepare equipment for hazard events: obtain additional equipment where needed; install equipment in safer locations (e.g. raise level to avoid flooding, place equipment in building, brace equipment); store non-essential equipment in safe place; proposition equipment where a need may arise (e.g. generator with fuel supply for back-up energy supply, ensure staff is familiar with operation of new equipment)
- Prepare levels of spare parts and consumables for events: store adequate levels of spares and consumables so periods of inaccessibility and poor supply can be bridged adequately; decentralise stocks to where materials are needed; store materials so they are protected

Organisation
- Put in place an Emergency Preparedness Plan with the systems needed for its proper execution
- Early warning system: set up an early warning system or connect to an existing early warning system
- Develop alternative strategies of service provision or limiting impact on society (i.e. Plan B): e.g. prepare for provision of water through trucking; prepare for installation of emergency latrines; preparation for adequate disposal of dangerous waste (e.g. medical waste, industrial waste, contaminated sludge). Identify and train people, store materials and equipment, prepare logistics and transport.
- Prepare changes in the organisation for dealing with emergency and recovery: procedures, standards and systems will possibly need change. Prepare alternative protocols adapted to changes in inputs (e.g. water quality, water availability, fuel shortage, consumables with new specifications). If insurance is possible it may be worth the investment. These changes have to be worked out beforehand and people affected have to be aware of the new systems

GENERIC MITIGATION AND PREPAREDNESS MEASURES

- Prepare for changes in demands from organisation: additional need for repair and maintenance (e.g. disposal of debris; removal of silt; repair of structures); change in demand (e.g. increased water production needed because of higher demand or increased loss rates; organisation having to cope with toxic industrial waste); change in service location (e.g. relocation of population that needs WASH services)
- The risk of outbreaks and service breakdown is large after a disaster occurrence; set up a system of quality monitoring and when issues are detected, rapid repair

Inputs

- Prepare for periods where revenue will drop: e.g. because users are not paying because of other priorities, inability to pay or poor access; politics may put pressure on WASH service providers, normally paying services may have to be provided free of charge
- Develop a good understanding of existing sources, improve existing sources, and look for alternative sources of water: e.g. assess water quality and yield (current and projected) of existing sources; repair/ upgrade existing sources; map all sources of water in a target area, including private water sources and sources used for industry and irrigation, assess usability and negotiate access to source in case of disaster; install or prepare installation of alternative sources
- Look for alternative resources, suppliers and service providers: e.g. prepare for changes in availability, quality, specifications and prices of consumables, spare parts, and equipment; make an inventory of suppliers of materials and consumables, negotiate priority, prices and quality; identify water trucks; identify vacuum trucks; negotiate access to vehicles. Try to negotiate with suppliers but be realistic in what can really be expected

Users

- Education of communities: on the use and maintenance of WASH systems in their communities (e.g. reporting of leakage; reporting on illegal connections or broken valves); on coping with reduced service level (e.g. hygiene promotion, household water treatment, excreta disposal)
- Identify and train persons in communities that can assist in maintaining service levels and recovery
- Prepare for user changes: e.g. demand, ability/ willingness to pay, attitude. Set up a communication strategy towards users

External infrastructure and service providers

- Include clauses in contracts for rented or loaned infrastructure, vehicles or equipment with regards to disasters and emergencies with regard to liabilities, continuity, price
- Prepare for changes in accessibility of structures: e.g. identify roads that are at risk and reinforce, look for alternative routes; purchase boats or negotiate access to boats in advance
- Prepare for reduced access to power supply, communication, waste management: e.g. install generators; if communication is crucial, introduce VHF/ UHF communication system; prepare for decentralised temporary waste disposal options

ANNEX 3

GENERIC MITIGATION AND PREPAREDNESS MEASURES

- Prepare for reduced access to external specialist support
- Link with emergency management bodies and emergency response services (e.g. public health services, fire department), other authorities (e.g. public works) and relevant organisations (e.g. NGOs, private sector), be realistic on their capacity to assist though

Other

- Identify other preparedness initiatives and try to connect initiatives; this is especially relevant for preparedness plans of community and critical services (e.g. public health services, education)
- Ensure WASH systems are adequate in shelters, schools, medical services
- Prepare for changes in context: e.g. politics, regulations, security
- Lobby for support in preparedness activities in society and for the WASH services (e.g. lobby public works to consolidate access roads, policy makers for more resources attributed to preparedness, support of authorities with transport)

ANNEX 4 POTENTIAL NEGATIVE EFFECTS OF SMALL-SCALE WASH SERVICES ON SOCIETY

WATER SUPPLY

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
Water scarcity or water quality degradation	Interruption of water supply to society caused by system breakdown (e.g. by hazard event, breakdown of infrastructure or materials, interruption of supply of consumables, funds or electricity)	• System has adequate level of resilience to threats • Monitoring of system
	Groundwater extraction at rates that cause drop of groundwater level, subsidence, saltwater intrusion, environmental degradation	• Unlikely that these issues can be adequately addressed in relief and recovery • Looking for alternative water sources • Introducing water saving measures • Monitoring of system
	Extraction of surface water at rates that cause reduced access to surface water, increased concentration of contaminants (biological and chemical), environmental degradation	• Unlikely that these issues can be adequately addressed in relief and recovery • Looking for alternative water sources • Introducing water saving measures • Monitoring of system
	Changes in local water resource management reducing water availability for community and environment (e.g. building a dam for irrigation purposes)	• Ensure that no changes in water resource management are introduced that will create issues • Monitoring of system
Pollution of human and natural environment	Waste generated in operation (e.g. sludge, degraded chemicals)	• Use methods that minimise waste production • Disposal of wastes in adequate way • Monitoring of system
	Pollutants released in the environment by hazard event or accident (e.g. flooding, heavy rains, destruction of chemicals reservoir in earthquake, fire	• Ensure potential pollutants are stored, transported and used in a way that prevents their release into the environment, also in case of a disaster event • Monitoring of system
Water supplied contains pathogens or chemicals	Water at the source is contaminated and treatment process is not able to remove pollution	• Looking for alternative water sources • Dilution of polluted water • Processes are in place that are able to remove pollution • Elimination of sources of pollution • Monitoring of system

WATER SUPPLY

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
	Contamination of the water supply in the water production process with pathogens or chemicals	• Put in place safeguards that prevent contamination • Ensure measures that can cope with water contamination are in place • Monitoring of water quality,
	Contamination of water supply in distribution system (e.g. leaks in system, adequate water pressure not maintained continuously)	• As far as possible leaks repaired and system protected in areas at risk • Adequate residual chlorine levels maintained • Continuous positive pressure in distribution network • Sources of pollution eliminated / isolated • Monitoring of system
Erosion/ landslide	Reservoirs, pipes, or other structures are leaking and leakage water is not drained adequately	• Leakage is prevented • System in place for adequate discharge of leakage water • Areas at risk are protected • Monitoring of system
Flooding	Leakage or accidents (e.g. rupturing dam) may cause flooding which can result in death and injury, loss in assets, livelihood degradation, erosion, landslide, reduced access	• Potential causes of leakage or accidents are eliminated • Ensure adequate drainage • Monitoring of system
Proliferation of insect vectors	Leakage water accumulates and provides breeding sites for mosquitoes	• Leakage prevented where water can accumulate • Proper drainage • Monitoring of system • Vector control • Monitoring of system
	Structures provide breeding sites for mosquitoes (e.g. standing water in empty drums, reservoirs accessible to insects)	• Structures minimise access to insect breeding sites • Removal, closing or filling of potential vector breeding sites • Vector control • Monitoring of system

WATER SUPPLY

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
Accident	Collapse of buildings, reservoirs, dams or other structures by inadequate building or installation standards or wrong placement, damage by hazard events, accidents, build-up of water pressure	• Adequate standards in construction or installation • Adequate location of placement of structure • In case of damage by hazard event or threat of hazard event: assessment of risk to structure and surroundings and if needed measures to contain risk • Monitoring of system
	Fire/ explosion/ toxic gas: chlorine generating products (e.g. HTH, chlorine gas) may cause fire or explosion, chlorine gas cylinders may release dangerous chlorine gas if damaged. Faulty electricity systems may cause fires	• Proper use and handling of products • Proper storage and protection of products • Safety measures to contain fires, and protect people and assets • Control of electric systems • Monitoring of system
Create antagonism within society	Activities in communities may create problems within a society if project organisation, implementation process (e.g. forming and empowering women's groups), or messages are not acceptable to community	• Project organisation, implementation process and messages are culturally acceptable • Monitoring of system

EXCRETA DISPOSAL

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
Pollution of human and natural environment	Inadequate excreta disposal systems can result in excreta polluting the environment. Depending on location and scale this may cause a number of issues: exposure of humans or animal hosts to excreta-related pathogens, pollution of water sources, contamination of food (e.g. vegetable gardens), mechanical vectors (e.g. flies, rats) have access to pathogens, degrading living conditions, discharge in open water can result in oxygen depletion leading to die-off of organisms in the water	• Standards respected in excreta disposal systems • Monitoring of system • Repair of damaged structures
Erosion/ landslide/ collapse	Leakage in off-site sanitation structures (traditional sewage systems, small-bore sewerage systems) can cause erosion, landslide, or collapse of soils. Leakage may be the result of damage to the system, inadequate standards, inadequate use (e.g. resulting in blockages)	• Use adequate standards • Monitoring of system • Prevention of leakage • Ensure reliable water supply

EXCRETA DISPOSAL

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
	Inadequately built pits of on-site sanitation structures may cause the collapse of soil	• Adequate standards
	On-site sanitation structures may overflow and cause erosion, landslide, or collapse of soils	• Adequate building standards • Monitoring of system • Take structure out of use in time • Prevention of leakage
Proliferation of insect vectors	Certain insects can proliferate if they have access to sludge or (diluted) sewage in the sanitary structures or if there is leakage or overflowing (e.g. flies, mosquitoes (Culex sp.))	• Adequate standards • Monitoring of system • Repair damaged structures • Vector control
Flooding	Leakage, overflowing caused by damage, poor construction standards or poor use of the system may cause flooding	• Adequate standards • Monitoring of system • Repair damaged structures • Reliable water supply needed for proper operation of structure
Accident	Collapse of buildings, pits, visit chambers by inadequate building or installation standards or wrong location, build-up of pressure, damage by hazard events, accidents	• Adequate standards in construction or installation • Proper location • Monitoring of system • In case of damage by hazard event or threat of hazard event: assessment of risk to structure and surroundings and if needed measures to contain risk
Create antagonism within society	Activities in communities may create problems within a society if project organisation, implementation process (e.g. forming and empowering women's groups), or messages are not acceptable to community	• Project organisation, implementation process and messages are culturally acceptable • Monitoring of system

HYGIENE PRACTICE

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
Create antagonism within society	Activities in communities may create problems within a society if project organisation, implementation process (e.g. forming and empowering women's groups), or messages are not acceptable to community	• Project organisation, implementation process and messages are culturally acceptable • Monitoring of system

VECTOR CONTROL

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
Pollution of human and natural environment	While many of the pesticides used nowadays are relatively safe to humans, they could, if used or disposed of poorly, result in intoxication	• Respect of safety measures • Monitoring of system • Use methods that minimise waste production • Disposal of wastes in adequate way
	Pesticides don't only kill vectors but also useful insects and aquatic animals (e.g. fish, shrimps). Poor use or disposal of pesticides can damage livelihoods or cause environmental issues	• Use of vector control and waste disposal methods that minimise negative impact on other species • Monitoring of system
Increase exposure to vectors	Poor use of chemical vector control can result in resistance of specific vectors to particular pesticides	• Use the pesticides in the proper way (e.g. dosage, distribution method) • Monitor emerging resistance in vector population and change pesticide when needed
	In places where the plague is an issue, rat destruction without prior flea control can force infected fleas to leave dead rats and infect persons	• In plague areas: flea control before rat control
Create antagonism within society	Activities in communities may create problems within a society if project organisation, implementation process (e.g. forming and empowering women's groups), or messages are not acceptable to community	• Project organisation, implementation process and messages are culturally acceptable • Monitoring of system

SOLID WASTE MANAGEMENT

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
Pollution of human and natural environment	Inadequate discharge of solid waste can pollute the environment. This is a major issue if there is no segregation of toxic and/ or industrial waste from household waste. This can lead to contamination of water supply, loss of livelihood and environmental degradation. Intoxication of persons using or manipulating toxic waste may also be an issue	• Use methods that minimise the risk of waste polluting the environment (e.g. sanitary landfill, avoid discharge of waste in drainage systems) • Monitoring of system • Encourage segregation of waste • Adequate standards
	Liquids leaching from waste disposal sites may contaminate groundwater and surface water	• Waste disposal sites have to be located so that they are protected from external water • Isolate waste from soil through installation of a barrier liner • Monitoring of system • Adequate standards

SOLID WASTE MANAGEMENT

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
	Waste disposal sites will often create issues of stench, smoke, insects, rats, stray dogs, flying waste, traffic jams	• Adequate location of waste disposal site • Covering waste with soil • Monitoring of system
Erosion/ landslide	Waste often ends up in natural, formal, or informal drainage systems, causing blockages and water finding its own way resulting in erosion and possibly collapse. Accumulated waste may also collapse and thus pose a risk	• Keep drainage channels free of waste • Monitoring of system • Adequate standards • Proper management of waste disposal site'
Flooding	Waste often ends up in natural, formal, or informal drainage systems, causing blockages and potentially flooding	• Keep drainage channels free of waste • Monitoring of system
Proliferation of vectors	Waste provides breeding sites for mosquitoes (Aedes sp.), house flies and rats. Organically contaminated water provides a breeding site for mosquitoes (Culex sp.).	• Improve solid waste management so as to reduce risk of breeding (cover waste with soil) • Vector control • Monitoring of system
	In areas where informal waste disposal sites are eliminated, rats may migrate to the community to seek refuge and food	• If rat population is large, control rats before elimination of waste disposal sites
Accident	Collapse of buildings, or other structures of the waste management system by inadequate building or installation standards or wrong placement, damage by hazard events, accidents	• Adequate standards in construction or installation • Adequate location of placement of structure • Monitoring of system • In case of damage by hazard event or threat of hazard event: assessment of risk to structure and surroundings and if needed measures to contain risk
	Urban waste management systems usually use trucks or tractors for collection and transport of waste. Heavy machinery is also used at waste disposal sites for levelling and covering the waste. These vehicles are often operating in sites that provide people with a livelihood (scavenging) and there is a high risk of accidents	• Training of operators • Working with scavengers on safety measures • Employing people who ensure safety at disposal sites while allowing people access to waste for their livelihood • Monitoring of system

SOLID WASTE MANAGEMENT

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
	In large waste disposal sites with scavengers there is a risk of accidents by collapse of waste	• Working with scavengers on safety measures • Employing people who ensure safety at disposal sites while allowing people access to waste for their livelihood • Monitoring of system
	Fire/ explosion/ toxic gas: methane is formed in landfills, and can potentially cause explosion, while not toxic carbon dioxide may form in confined areas and displace oxygen, causing a threat to people. Waste usually contains combustible materials so fire is a risk, depending what type of waste is burning toxic gases may be formed	• Proper disposal of waste • Installation of vent pipes • Safety measures • Monitoring of system • Adequate standards
Create antagonism within society	Activities in communities may create problems within a society if project organisation, implementation process (e.g. forming and empowering women's groups), or messages are not acceptable to community	• Project organisation, implementation process and messages are culturally acceptable • Monitoring of system

DRAINAGE

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
Water scarcity	Larger drainage systems may reduce groundwater recharge	• Unlikely that these issues can be addressed in relief and recovery
	Drainage systems may eliminate water sources that were used for the livelihood of households	• Unlikely that these issues can be addressed in relief and recovery
Pollution of human and natural environment	The 'first flush', or initial stormwater that runs off an area will often be polluted. This water will introduce pollutants in surface water and possibly to groundwater. Waste generated in operation (e.g. sludge, degraded chemicals)	• Unlikely that these issues can be addressed in relief and recovery
	The drainage system will transport pollutants present in the system and discharge these into surface water (e.g. discarded vehicle oil, leachate from solid waste, excreta, organic waste)	• Unlikely that these issues can be addressed in relief and recovery
Erosion/ landslide/ collapse	Waste and soil often ends up in drainage systems, causing blockages and water finding its own way resulting in erosion and possibly collapse	• Keep drainage channels free of waste and soil • Monitoring of system • Adequate standards

DRAINAGE

ISSUE	POTENTIAL NEGATIVE EFFECTS	POSSIBLE MEASURES
	Where channels are not lined, storms can result in rapid erosion of the sides, and structures may be at risk of collapse	• Unlikely that these issues can be addressed in relief and recovery • Lining channels • Monitoring of system
Flooding	Waste and soil often ends up in drainage systems, causing blockages and potential flooding	• Keep drainage channels free of waste and soil, design channel system so that blockages are unlikely • Monitoring of system • Adequate standards
	Drainage systems are designed to cope with a storm of a certain intensity; a storm with a higher intensity will usually result in flooding as the system is not able to cope with the amount of runoff produced	• Unlikely that these issues can be addressed in relief and recovery
	A drainage system in one area may discharge its runoff so rapidly that the drainage system downstream is overwhelmed, and flooding occurs in downstream communities	• Drainage systems should be looked at in an integral way, from point where runoff is produced to where it is discharged in surface water • Monitoring of system
Proliferation of insect vectors	Waste and soil in channels and defects in the system will result in standing water, which can provide breeding and/ or resting sites for mosquitoes, house flies and possibly rats	• Keep channels clean • Repair of system • Vector control • Monitoring of system
Accident	Collapse of drainage structure by inadequate building or installation standards or wrong placement, damage by hazard events, accidents, erosion, degradation over time, build-up of water pressure	• Adequate standards in construction or installation • Adequate location of structure • In case of damage by hazard event or threat of hazard event: assessment of risk to structure and surroundings and if needed measures to contain risk, proper maintenance • Monitoring of system
	Drainage systems are often not well protected and accidents around them are a risk (e.g. people falling in channel)	• Adequate standards in construction or installation • Adequate location of placement of structure • Monitoring of system
Create antagonism within society	Activities in communities may create problems within a society if project organisation, implementation process (e.g. forming and empowering women's groups), or messages are not acceptable to community	• Project organisation, implementation process and messages are culturally acceptable • Monitoring of system

ANNEX 5

EXAMPLES OF DRR INTEGRATION IN WASH

What follows are summary descriptions of a number of WASH projects that have mainstreamed DRR in the emergency relief and recovery phases. There are good practice and poor practice examples, and there are examples of 'do no harm'.

PUBLIC HEALTH PROJECT – KENYA (2007/08) - OXFAM GREAT BRITAIN

In 2007/08 Oxfam Great Britain developed a public health project in the drought and flood-prone pastoral region of Wajir District in north-eastern Kenya. The project lasted 6 months, and aimed to reduce the vulnerability of pastoralists to drought by improving access to water, hygiene and nutrition awareness, and sanitary practices.

Access to water was improved by installing additional water points. Handpumps and solar pumping systems were installed. Water pans were prepared. To improve water quality, locally made bio-sand filters were introduced. This was accompanied with hygiene promotion activities. Work was also done on improving the capacity of local water authorities and water user associations.

The project significantly improved the resilience of 35,000 persons. It also improved the quality of life of many users of the systems. Structures were adapted to the local hazards and context; they were strategically placed, and locations were in areas were the risk was reduced. Wells were made so as to resist flooding and its effects (e.g. siltation). The risk of the water user associations not having enough funds to get through periods of drought was identified, and systems were set up to improve the management of surplus funds generated in non-drought periods. These funds were also used to access new resources and develop new skills. Oxfam also worked with the communities on clarifying the rights people had with regards to water, and the obligations the water authorities had towards them in times of drought and flood.

COMMUNITY WATER SECURITY PROGRAM – MYANMAR (2008/2009) – INTERNATIONAL RESCUE COMMITTEE (WRITTEN BY BEN HARVEY, THE IRC)

On May 2-3, 2008, the severe tropical cyclone Nargis struck Myanmar and swept through the Ayeyarwady delta region and the capital city of Yangon, devastating already poor and vulnerable communities. During the initial months of the response, the IRC's Environmental Health (EH) team focused its efforts on responding to immediate water, sanitation and hygiene needs of disaster affected and internally displaced populations to prevent the outbreak of disease and maintain healthy living conditions. Water sources were protected, emergency water supplies were established, emergency latrines were constructed and hygiene kits and family kits were distributed. After the emergency response period, the IRC's Environmental Health program incorporated Disaster Risk Reduction (DRR) principles to reduce the vulnerabilities and increase the capacities of communities to prepare and respond to future potential disasters. Traditional water sources (rainwater ponds and wells) were found to be particularly susceptible to damage and pollution during cyclones. Therefore the IRC's community water security strategy concentrated on reducing vulnerability through the construction of cyclone resistant 45,000 liter and 11,000 litre ferrocement rainwater harvesting tanks and distributing colloidal silver ceramic water filters. The ferrocement reservoirs were sited in locations where people had traditionally gathered following crisis (schools, health centres and monasteries).

The IRC provided three skilled masons to each community in addition to construction materials. Storage and security of materials along with labour for the project was provided by the community. The reservoirs also gave the advantage of augmenting community water supplies during the dry season. A total of 66 communities benefitted from cyclone resistant rainwater harvesting tanks. In addition over 10,000 colloidal silver ceramic water filters were distributed to vulnerable households. Finally, in order to increase the capacities of communities, first aid responders and community hygiene promoters were identified, trained, equipped and mentored throughout the project duration.

LIVELIHOODS AND SHELTER PROJECT – INDIA (2010/11) – CARE INDIA

In May 2009 Cyclone AILA hit India's south-eastern coast, affecting almost 6.6 million persons across 18 Districts. Homes were destroyed, as were standing crops, fisheries and livestock. Water sources were contaminated with saline water. Traditionally the population was largely dependant on surface water ponds for their water supply. These ponds were now filled with saline water. Five months after AILA, many villages were still inundated, and needs in the community with regards to shelter, food, and WASH services were very high.

The project developed by CARE India worked on strengthening livelihoods and improving shelter. Part of the project was to supply WASH services to communities. The vulnerability of the communities to future flooding was high, and therefore the handpumps that were installed were raised. This would ensure that the pumps would not be affected during flooding, and that they would remain operational in case of inundation. The raised handpumps were adapted to users with disability.
Figure 10 shows an example of one of the handpumps installed.

The project covered hardware, software, and community organization. Potential users of the system were involved in hygiene promotion activities and in awareness activities on proper use and cleanliness of the handpumps and environment. Users Committees which consisted of locally elected representatives were formed, and were trained in operation and maintenance of the systems, and in basic management and administration tasks needed to keep these operational. A strong engagement of the community, combined with a cost recovery system assisted in the sustainability of the systems.

Figure 12: One of the raised handpumps installed in the CARE India project

DROUGHT MITIGATION – INDIA – DISCIPLESHIP CENTRE (DC) IN PARTNERSHIP WITH TEARFUND [22]

In a project aimed at making communities more resilient to drought and cyclones DC have set up Village Development Committees (VDCs) in five villages in Rajastan. These VDCs are made up of men and women, and include representatives of different castes.

One of the major issues the VDCs brought forward was shortage of drinking water. As drilling more boreholes was not really an option (the Indian government is opposed to installing more boreholes as groundwater levels are dropping), cisterns were built to store rainwater. The cisterns store 40,000 litres and are shared by three families. The cisterns normally contain enough water to get the households through the dry season, and can be used as a water reservoir if water would have to be brought in by water truck in case of drought.
One cistern was built in every village. The scheme was well received and the VDCs, supported by DC, took the idea to the local government, who committed to building an additional 10 cisterns in the near future.

A traditional way to conserve water was the construction of rainwater bunds, one to two metres high earth walls built around a field to contain rainwater. The project assisted in preparing one field surrounded by bunds for one of the village widows. The yield of the field doubled in the first year and other village members are now also looking into the possibility to install bunds to improve water management in the fields.

The VDCs also resulted in the empowerment of vulnerable groups in the communities, and giving them a voice within the community and towards government.

DEVELOPMENT AND RISK REDUCTION – INDIA – EVANGELICAL FELLOWSHIP OF INDIA COMMISSION ON RELIEF (EFICOR) IN PARTNERSHIP WITH TEARFUND[23]

Khammam district in Andhra Pradesh is one of the hottest districts in southern India. The main hazards facing the district are flooding and drought. When they occur, handpumps are submerged during flooding events and during drought the boreholes dry up.

EFICOR has worked on increasing the resilience in a number of villages in Khammam district. In ten villages EFICOR has established Disaster Management Committees (DMCs) and formed and trained an emergency response task force. Other groups were also set up (e.g. Women's Self Help Groups). Disaster risk assessments were conducted and contingency plans made with the communities.
The project worked on food security by introducing crops more adapted to the local hazards and reforestation. Besides these measures water supply was made more resilient by installing raised handpumps with deeper boreholes in 7 villages, training people in handpump maintenance and repair, and providing toolkits. Diesel powered irrigation pumps to mitigate the effects of drought were installed in two villages.

The work with the community and strengthening of community organisation has left a mark. Community members expressed that hazard events had less impact on their lives, not because of a change of intensity or duration of the floods, but because they feel the community is better organised to deal with the consequences. Because of the work of the Women's Self Help Groups women also have received much more of a voice in community affairs.

22 Adapted from http://tilz.tearfund.org/webdocs/Tilz/Topics/DRR/Drought%20Mitigation%20in%20Rajasthan.pdf
23 Adapted from http://tilz.tearfund.org/webdocs/Tilz/Topics/Risk%20reduction%20in%20Andhra%20Pradesh%20-%20smaller.pdf

FLOOD EMERGENCY RESPONSE – INDIA (2007/08) – OXFAM INDIA

In 2007 Oxfam India developed a relief intervention in response to the Bihar floods. This was followed up in 2008 by a flood recovery programme. One of the things that became clear during the assessment was that women had poor access to adequate bathing facilities when displaced.

To address this particular need, 10 bathing cubicles were made in the most vulnerable communities. These cubicles were raised so as to be above the flood line level and incorporated a handpump. This approach meant that users had year-round access to private washing places and a safe water supply resilient to floods. This action was part of a larger intervention that included hygiene promotion, capacity building of community based organisations and lobbying for the replication of the bathing cubicle system by the authorities.

This action is a good example of an intervention where DRR is integrated or mainstreamed in a standard WASH project.

For more information contact Zubin Zaman; Humanitarian Programme Manager for Oxfam India, New Delhi

CHOLERA RESPONSE – MOZAMBIQUE (1998)

In 1998 a large international NGO responded to a major cholera outbreak in the city of Beira in Mozambique. Part of the response consisted of setting up a water trucking scheme that supplied water to several slum areas with inadequate sanitation and poor water availability. Water distribution points were made with bladder tanks raised by placing them on purpose-made sand mounds and transport containers.

One of the water distribution points was to be installed besides a school. Local workers from the community made the sand mound under the supervision of a foreman. Contrary to instructions the 1.2 metres high sand mound was made against a wall of the school. On the other side of the unreinforced brick wall were crowded classrooms. The 15 m3 bladder tank had been placed against the wall. The bladder and tapstand system were installed and a water truck on its way to fill the reservoir was on its way when the coordination team visited. On seeing the threat of collapse of the wall and a full bladder rolling into a full classroom, the water truck was diverted to another distribution site, and the instruction were left to immediately remove the load from the wall and install the platform some metres from the buildings. The distribution started one day later than planned, but a possible disaster was averted.

REFERENCES AND FURTHER READING

GENERAL BACKGROUND WASH

NO.	TITLE	DESCRIPTION	PUBLISHED BY – YEAR	SOURCE
R1	Water, Sanitation and Hygiene for populations at risk	Everything you ever wanted to know on WASH in emergency and recovery; or almost...	Action Contre la Faim/ Hermann: Paris (France) - 2005	http://www.actionagainsthunger.org/resources/summary/Water+Sanitation+and+Hygiene+for+Populations+at+Risk
R2	Engineering in emergencies : A practical guide for relief workers (2nd ed.)	Authors: Jan Davis and Robert Lambert Good introduction in WASH in emergencies	Intermediate Technology Publications Ltd: Rugby (UK) - 2002	Hard copy
R3	Emergency water sources: Guidelines for selection and treatment (3rd ed.)	Authors: Sarah House and Bob Reed Guideline on the water source selection and treatment in the emergency and recovery phase	Water, Engineering and Development Centre – Loughborough University: Loughborough (UK) - 2004	http://wedc.lboro.ac.uk/knowledge/details.php?book=978-1-84380-069-9
R4	Emergency sanitation: Assessment and programme design	Authors: Peter Harvey, Sohrab Baghri and Bob Reed Guideline on assessment, excreta disposal, solid waste management, drainage, hygiene promotion and programming in the emergency and recovery phase	Water, Engineering and Development Centre – Loughborough University: Loughborough (UK) - 2002	http://wedc.lboro.ac.uk/knowledge/details.php?book=978-1-84380-005-7
R5	Out in the cold: Emergency water supply and sanitation for cold regions (3rd ed.)	Authors: Mark Buttle and Michael Smith Guideline on WASH in emergency and recovery in cold climates	Water, Engineering and Development Centre – Loughborough University: Loughborough (UK) - 2004	http://wedc.lboro.ac.uk/knowledge/details.php?book=978-1-84380-077-4
R6	Controlling and preventing disease: The role of water and environmental sanitation interventions	Authors: Erik Rottier and Margaret Ince Guideline on WASH-related infections and the control through WASH actions	Water, Engineering and Development Centre – Loughborough University: Loughborough (UK) - 2003	http://wedc.lboro.ac.uk/knowledge/details.php?book=978-0-906055-90-8
R7	Vector control: Methods for use by individuals and communities	Authors: Jan A. Rozendaal Guideline on vector control	World Health Organisation (WHO): Geneva (Switzerland) - 1997	http://whqlibdoc.who.int/publications/1997/9241544945_eng.pdf
R8	WHO Publications on Water, Sanitation and Hygiene	Access to resources covering WASH, and public health as related to WASH	World Health Organisation (WHO)	http://www.who.int/water_sanitation_health/publications/en/index.html
R9	UNICEF Water, Sanitation and Hygiene publications	Access to WASH resources	United Nations Children's Fund (UNICEF)	http://www.unicef.org/wash/index_documents.html
R10	The Sphere project: Humanitarian charter and minimum standards in disaster response – 4. Water, Sanitation & Hygiene promotion	Standards and tools for accountability on WASH in emergencies	The Sphere project: Geneva (Switzerland) - 2004	http://www.sphereproject.org/component/option,com_docman/task,cat_view/gid,17/Itemid,203/lang,english/

KEY ORGANISATIONS, GENERAL INFORMATION RELATED TO DISASTERS AND VERTICAL PORTALS RELATING TO DISASTERS

NO.	TITLE	DESCRIPTION	PUBLISHED BY – YEAR	SOURCE
R11	UN/ISDR Home page	Access to the UN/ISDR website	United Nations International Strategy for Disaster Reduction (UN/ISDR)	http://www.unisdr.org/
R12	ProVention consortium	Access to the ProVention website	ProVention consortium	http://www.proventionconsortium.org/
R13	EM-DAT – The International Disaster Database	A web-based database on disasters since 1900. The site also gives access to publications on disasters, pre-made graphs and maps, and allows users to create personalised datasets.	Centre on the Research on the Epidemiology of Disasters (CRED)	http://www.emdat.be/
R14	PreventionWeb – Professional resources	Access to training materials, publications, upcoming events, jobs and more with regards to DRR	PreventionWeb	http://www.preventionweb.net/english/professional/
R15	Pan American Health Organization (PAHO) – Publications catalogue	Access webpage to the publications of PAHO relating to disasters. PAHO has a wealth of publications that cover hazard types, sectors and public health in emergencies.	Pan American Health Organization (PAHO)	http://www.disasterpublications.info/english/index.php
R16	OCHA Disaster Response Preparedness Toolkit	A website providing access to summary information on different hazards, response preparedness and funding mechanisms	UN Office for the Coordination of Humanitarian Affairs (OCHA)	http://ocha.unog.ch/drptoolkit/index.html

GENERAL BACKGROUND DRR & DRR MAINSTREAMING

NO.	TITLE	DESCRIPTION	PUBLISHED BY – YEAR	SOURCE
R17	UN/ISDR Terminology on Disaster Risk Reduction (2009)	Definitions of terms used in DRR	United Nations International Strategy for Disaster Reduction (UN/ISDR)	http://www.unisdr.org/eng/library/lib-terminology-eng.htm
R18	At Risk: Natural hazards, people's vulnerability and disasters (2nd ed.)	Authors: Ben Wisner, Piers Blaikie, Terry Cannon and Ian Davis In-depth background on disasters, the PAR model, and DRR in different hazard types.	Routledge; London (UK) - 2004	Hard copy
R19	Introduction to international disaster management	Author: Damon P. Coppola Reference work on disasters, DRR and the emergency management cycle	Elsevier; Amsterdam (The Netherlands) - 2007	Hard copy

GENERAL BACKGROUND WASH

NO.	TITLE	DESCRIPTION	PUBLISHED BY – YEAR	SOURCE
R20	Good Practice Review: Disaster risk reduction: Mitigation and preparedness in development and emergency programming	Author: John Twigg Background on the DRR principles and approach, and DRR interventions.	Humanitarian Practice Network (HPN) - Overseas Development Institute (ODI) London (UK) - 2004	http://www.odihpn.org/publistgpr9.asp
R21	Tools for mainstreaming disaster risk reduction: guidance notes for development organisations	Authors: Charlotte Benson, John Twigg and Tiziana Rossetto A set of tools on the mainstreaming of DRR in the programming of development organisations	ProVention consortium; Geneva (Switzerland) - 2007	http://www.proventionconsortium.org/themes/default/pdfs/tools_for_mainstreaming_DRR.pdf
R22	Mainstreaming disaster risk reduction: A tool for development organisations	Authors: Sarah La Trobe and Prof. Ian Davis A small guideline on mainstreaming of DRR in programming and the monitoring of level of integration	Tearfund; Teddington (UK) - 2005	http://www.tearfund.org/webdocs/Website/Campaigning/Policy%20and%20research/Mainstreaming%20disaster%20risk%20reduction.pdf

DRR GUIDELINES AND TOOLS

NO.	TITLE	DESCRIPTION	PUBLISHED BY – YEAR	SOURCE
R23	CRA Toolkit: Glossary of Terms	A listing of different approaches in the assessments of hazards, vulnerability and capacity, and specific assessment methods and tools.	ProVention consortium	http://www.proventionconsortium.org/?pageid=45
R24	Community Risk Assessment methodologies and case studies	A collection of manuals, guidelines, lessons learned and case studies on DRR of a multitude of different organisations	ProVention consortium	http://www.proventionconsortium.org/?pageid=43
R25	Disaster management resources corner	Access to IFRC disaster management publications	International Federation of Red Cross and Red Crescent Societies (IFRC)	http://www.ifrc.org/what/disasters/resources/publications.asp
R26	Vulnerability and capacity assessment (VCA)	A set of resources introducing Vulnerability and Capacity Assessment, a toolbox, training and lessons learned; several documents are also available French and Spanish	International Federation of Red Cross and Red Crescent Societies (IFRC)	http://www.ifrc.org/what/disasters/resources/publications.asp
R27	Reducing risk of disaster in our communities	Authors: Paul Venton and Bob Hansford A guideline on the application of the community-based DRR	Tearfund; Teddington (UK) - 2006	http://www.proventionconsortium.org/themes/default/pdfs/CRA/Tearfund2006_meth.pdf

GENERAL BACKGROUND WASH

NO.	TITLE	DESCRIPTION	PUBLISHED BY – YEAR	SOURCE
R28	Participatory Capacity and Vulnerability Analysis Training Pack	Authors: Edward Turvill and Honorio B. De Dios A training pack for Participatory Capacity and Vulnerability Analysis	Oxfam GB: Oxford (UK) - 2009	Hard copy
R29	Approaches to disaster risk reduction	Guideline on the application of DRR in communities	Concern - 2005	http://www.concernusa.org/media/pdf/2007/10/Concern_Approachesto-DRR%20paper%20-%20final.pdf
R30	Climate Vulnerability and Capacity Analysis Handbook	Authors: Angie Dazé, Kaia Ambrose and Charles Ehrhart A guideline on adaptation to Climate Change; the approach presented integrates DRR and Climate Change adaptation	CARE International - 2009	http://www.careclimatechange.org/index.php?option=com_content&view=article&id=25&Itemid=30
R31	Drought Cycle Management: A toolkit for the drylands of the greater horn of Africa	A guideline on working in drought-prone areas	IIRR, CordAid and Acacia Consultants - 2004	Hard copy
R32	Disaster Risk Reduction in the project cycle management: A tool for programme officers and project managers	A brief document covering the integration of DRR in the project cycle	Swiss Agency for Development and Cooperation (SDC) -	http://www.riskandsafetynet.ch/en/Disaster_Risk_Reduction/Publications/Tools_from_SDC

DRR INTEGRATION IN WASH

NO.	TITLE	DESCRIPTION	PUBLISHED BY – YEAR	SOURCE
R33	¿Cómo reducir el impacto de los desastres en los sistemas de agua y saneamiento rural?	A Spanish-language guideline on the effects of specific disasters on rural WASH systems. The guideline presents very specific, often illustrated, measures that can be taken to improve the resilience of WASH systems.	Organización Panamericana de la Salud (PAHO)	http://www.paho.org/spanish/dd/ped/impactodesastresaguarural.htm
R34	Preparativos en salud, agua y saneamiento para la respuesta local ante desastres	A Spanish-language guideline on public health with regards to disasters. The coverage of WASH is not deep, but the guideline gives a broad and useful overview of WASH with regard to health.	Organización Panamericana de la Salud (PAHO)	http://www.paho.org/spanish/dd/ped/preparativosrespuestalocal.htm
R35	Minimizando el daño sismico: guia para los operadores de agua	A Spanish-language guideline for water utilities covering risk of earthquakes to water supply systems and mitigation and preparation measures	Organización Panamericana de la Salud (PAHO)	http://www.disaster-info.net/watermitigation/e/publicaciones/Redsismos/index_en.html

GENERAL BACKGROUND WASH

NO.	TITLE	DESCRIPTION	PUBLISHED BY - YEAR	SOURCE
R36	Natural Disaster Mitigation in Drinking Water and Sewerage Systems: Guidelines for Vulnerability Analysis	A guideline on the effects of specific disasters on larger WASH systems and some measures that can be taken to avoid negative impact. Despite the title the focus is largely on water supply systems. In annex 2 a case study of a vulnerability analysis of a water supply system is presented.	Pan American Health Organization (PAHO)	http://www.paho.org/English/DD/PED/natureng.htm
R37	The challenge in disaster reduction for the water and sanitation sector: Improving quality of life by reducing vulnerabilities	A higher-level document looking at the links between WASH and disasters	Pan American Health Organization (PAHO)	http://www.paho.org/english/dd/ped/DesafiodelAgua.htm
R38	Integrated Risk Management to Protect Drinking Water and Sanitation Services Facing Natural Disasters	Document describing the linkages between disasters and WASH services and disaster management with regards to WASH services	IRC International Water and Sanitation Centre - 2008	http://www.irc.nl/page/40163

WATER SAFETY PLANS

NO.	TITLE	DESCRIPTION	PUBLISHED BY - YEAR	SOURCE
R39	A Brief Guide to Drinking Water Safety Plans	A brief description of water safety plans	Drinking Wate Inspectorate (DWI) - 2005	http://www.dwi.gov.uk/guidance/Guide%20to%20wsp.pdf
R40	Guidelines for drinking-water quality, third edition, incorporating first and second addenda – Volume 1: recommendations – Chapter 4: Water Safety Plans	Description of Water Safety Plans, describing elements relevant to different water supply systems, guidance on setting up monitoring processes and corrective procedures	World Health Organisation (WHO): Geneva (Switzerland) – 2008	http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html
R41	Water Safety Plan Manual: Step-by-step risk management for drinking-water suppliers	Authors: Bartram J. et al. A step-by-step manual on making a Water Safety Plan	World Health Organisation (WHO): Geneva (Switzerland) - 2009	http://www.who.int/water_sanitation_health/publication_9789241562638/en/index.html

ADDITIONAL RESOURCES

NO.	TITLE	DESCRIPTION	PUBLISHED BY - YEAR	SOURCE
R42	Reliefweb – Countries and emergencies	Information on current disasters and emergencies	UN Office for the Coordination of Humanitarian Affairs (OCHA)	http://www.reliefweb.int/rw/dbc.nsf/doc103?OpenForm
R43	AlertNet	News coverage	Thomson Reuters Foundation	http://www.alertnet.org/index.htm

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