Environmental Indicators of Climate Risks to Inclusive WASH

Water For Women

Building Climate Change Resilience and Adaptation in Inclusive WASH

UTS Institute for Sustainable Futures

Australian Aid

In brief

This learning resource is intended to help water, sanitation and hygiene (WASH) service authorities and their supporting civil society organisations (CSOs) to reflect on the indicators they could use in their own contexts to monitor climate risks to WASH. It provides tables of climate risks for WASH and simple environmental indicators that WASH service authorities can use to trigger action to prevent negative impacts on WASH. It also contains advice on important aspects to consider when putting indicators into practice.

WASH CSOs that want to support government service authorities to proactively monitor and respond to emerging risks to WASH from climate change can use this learning resource as a tool to reflect on elements needed to set up or upgrade a monitoring system.

About Water for Women

Water for Women supports improved health, gender equality and wellbeing in Asian and Pacific communities through socially inclusive and climate-resilient water, sanitation and hygiene (WASH) projects and research. It is the Australian Government's flagship WASH program, investing AUD154.9 million over seven years. Water for Women is partnering with civil society organisations, research organisations and local partners to deliver 40 projects in 16 countries from 2018 to 2024. Knowledge and learning are central to Water for Women, positioning the Fund as an important contributor to global knowledge development and sharing in inclusive and climate-resilient WASH. Water for Women's Learning Agenda promotes collaborative learning, knowledge development and sharing to support long-term transformative change to WASH policy and practice globally.

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Front cover: Women collect water during the dry season in Lao PDR. Credit: SNV / Bart Verweiji

Abbreviations

CDI	Combined Drought Indicator
CSO	Civil Society Organisation
DHS	Demographic and Health Survey
DRR	Disaster Risk Reduction
EDI	Effective Drought Index
EM-DAT	Emergency Events Database
IGRAC	International Groundwater Resources Assessment Centre
GIS	Geographic Information System
JMP	Joint Monitoring Programme
NDVI	Normalised Differential Vegetation Index
OD	Open Defecation
MICS	Multiple Indicator Cluster Survey
PDSI	Palmer Drought Severity Index
SPI	Standardized Precipitation Index
UNESCO	United Nations Educational, Scientific and Cultural Organization
WASH	Water, Sanitation and Hygiene
WMO	World Meteorological Organization
WSP	Water Safety Plan

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Introduction

Climate change is altering the water cycle and driving extreme weather events in unprecedented ways. These environmental changes pose significant risks for water, sanitation and hygiene (WASH) services, with the risks often being greatest for marginalised people. Further, due to limitations in the accuracy of climate projections at local levels, it can be difficult to anticipate when and where risks to WASH access will become high at the household level.

Indicators of the current conditions of the natural and built environment can be monitored to detect emerging climate risks to WASH access. Indicators are simple, measurable characteristics that can be used to trigger proactive action to protect WASH services from detrimental climate impacts. For instance, WASH service authorities (government agencies responsible for ensuring that everyone has safe WASH access) and civil society organisations (CSOs) can monitor environmental indicators on an ongoing basis in order to detect when particular climate risks have become worryingly high and require action to avoid negative impacts.

This learning resource summarises a range of indicators that WASH service authorities and their CSOs can use to monitor the key risks of six climate hazards to household WASH access. Specifically, the indicators pertain to changes in the natural or built environment that may be outside the sphere of control of a WASH program. It also provides guidance on the contexts in which each indicator is most relevant, suggested data sources for measuring the indicators, and advice on supporting WASH service authorities to make the most use of the indicators. This resource is not a prescriptive step-by-step guide for setting up a monitoring system, but rather a resource for WASH service authorities and CSOs to reflect on climate risks that could be monitored.

The learning resource is structured as follows:

- **how to use this learning resource:** advice for referring to the learning resource content
- **defining thresholds for indicators:** how to know when an indicator has a reached a point when action is required
- **identifying vulnerable populations:** how to know which groups of people are most vulnerable, because risk is not experienced equally
- **limitations of using indicators:** what indicators can and cannot tell us, and what more is needed to monitor climate risks and impacts
- **indicators for monitoring climate risks to WASH:** suggested indicators for WASH service authorities and CSOs to use to monitor specific climate risks to WASH, and potential data sources for indicators.

How to use this learning resource

This learning resource is intended to help WASH service authorities and their supporting CSOs to reflect on the indicators they could use in their own contexts to monitor climate risks to WASH. Not all indicators, climate risks, and data sources presented in this guidance note will be relevant in every context. Hence, readers should treat the Indicators for monitoring climate risks to WASH section as a menu of options to be considered insofar as they are relevant, useful and feasible in their context. It may be practicable to monitor only a few indicators.

The indicators in this resource pertain to changes in the natural or built environment (not to impacts/outcomes of climate hazards or social vulnerability). WASH service authorities and CSOs can monitor these indicators so they are alerted to act to pre-emptively reduce climate risks to household WASH access. This learning resource focuses on dimensions of household WASH access that are covered in the JMP core questions on water, sanitation and hygiene for household surveys (2018 update).

Climate risks — defined as the potential negative outcomes of climate hazards — are a product of the likelihood that a climate impact occurs and the severity of its consequences if the impact occurs. This learning resource focuses on the likelihood component of risk. That is, the indicators in this guidance note can be used to detect whether a particular climate risk (a potential negative outcome) is becoming increasingly likely to turn into an impact (an actual negative outcome).

To identify which indicators are useful to monitor, WASH service authorities and their CSO partners will need to carry out a risk identification/assessment process to identify the key risks to WASH systems in their areas and for whom. (This learning resource does not provide guidance on this initial risk identification/assessment process). Once the key climate risks for WASH systems in the area are known, the relevant WASH service authority and/or CSO can review the lists of indicators and climate risks in this resource and identify the priorities to monitor. Prioritisation will depend on which risks are most relevant and potentially harmful, which indicators are feasible for WASH service authorities to monitor, and which indicators can feasibly be acted on in a given context.

The WASH service authority itself does not have to collect the data – data may be collected by other local, national or international agencies – but the WASH service authority must have access to it. In fact, as much as possible, the WASH service authority should rely on data that is already being collected. Cross-sectoral collaboration (for example, with disaster risk reduction (DRR) agencies or other agencies with well-developed monitoring programs) is key for opening access to existing data sources. Other sectors may also have their own indicators that can be used as proxies for indicators in this guidance note (for example, water shortage indicators used by the agriculture sector may also indicate water shortages for WASH uses).

To put the indicators into practice, much work is needed. The Defining thresholds for indicators, Identifying vulnerable populations, and Limitations of using indicators sections provide advice on some aspects of operationalising a monitoring program that WASH service authorities and CSOs will need to consider. However, WASH service authorities and CSOs will need to consider other coordination, logistical and financial factors to start or update a climate risk monitoring program, and the needs and opportunities will vary from context to context. Ideally, climate risk indicators are incorporated into an existing government information management system.

The purpose of monitoring climate risk indicators is to flag to authorities when a risk has become high enough to warrant proactive action to prevent impacts. Examples of adaptation options when a risk becomes high are provided in the Indicators for monitoring climate risks to WASH section, but responsible agencies will need to carry out further work to identify appropriate responses and set up systems for their implementation. Cross-sectoral collaboration on the formation and resourcing of an action plan that outlines roles and responsibilities for alerting the need for action and for implementing responses may be helpful. This will require an in-depth process tailored to a country context (not covered in this learning resource).

Defining thresholds for indicators

A threshold (or trigger) is a specific value or level of an indicator that, when reached, initiates a response. For example, if groundwater levels become too low, an agency needs to provide support to households (for example, through provision of packaged water) to prevent water scarcity. The threshold defines 'too low' in a specific context– which is important, because it alerts stakeholders that responses must be implemented.

Every indicator should have at least one threshold, and thresholds often need to be specific to a geographic or social context. For example, what is considered too low for groundwater levels in one context may be different in another context. Thresholds can come in levels – such as low, medium, and high – to indicate differing levels of urgency or types of responses needed. Figure 1 shows basic examples of thresholds for a reduced precipitation indicator.

Level	Threshold	Response
Low	Seasonal precipitation < 75% of normal precipitation for this period	Alert response agencies that emergency measures may need to be activated
Medium	Seasonal precipitation < 50% of normal precipitation for this period	Alert public of possible water shortages and encourage storing water
High	Seasonal precipitation < 25% of normal precipitation for this period	Deploy water trucks or packaged water to affected areas

Figure 1. Examples of thresholds for an indicator of the risk of reduced precipitation creating shortfalls in local water supplies

There are different methods for defining appropriate threshold(s) for the indicator in a particular context. One such method is descriptive statistics or associational statistical analysis (such as correlation or regression analysis). For example, a study could analyse the relationship between heavy rainfall and E. Coli levels in water sources to determine what level of rainfall causes concerning levels of contamination. However, this type of study can be costly and time-consuming. Alternatively, expert opinion of professionals or locals with substantial experience in the area can be used to estimate thresholds. For example, locals may know that water points become inundated when a river reaches a certain level; this may involve a trial-and-error approach to refine the threshold over time. Thresholds do not have to be precise quantifiable numbers, but can alert authorities to investigate a risk, especially before deploying costly interventions.

Thresholds should be set to the needs of the most vulnerable groups in a given context. Some groups of people may have different thresholds. For example, lower-income households may experience water stress due to reduced rainfall sooner than higher-income households that can purchase more packaged water, or may live in areas that flood more quickly than others. Investigations used to define thresholds should factor in the experiences of diverse groups and set a threshold for action for any group that needs assistance.

Thresholds may need to be adjusted over time, especially if long-term adaptations are implemented. For example, if an improved groundwater abstraction and management scheme is implemented in an area, the threshold for the reduced rainfall indicator may be raised (for example, < 10% of normal precipitation instead of < 25%) to reflect the increased resilience of the new water supply.

Identifying vulnerable populations

Not everyone experiences climate risks in the same way. Due to socioeconomic factors, including social structures and norms, some people are more vulnerable (that is, more susceptible or predisposed to harm) to climate hazards than others. Although this learning resource does not provide in-depth coverage of vulnerability assessments and identification of the most vulnerable groups, these are useful for designing adaptations and targeting resources to people most in need.

Social vulnerability is complex and generally requires a mixed-methods approach to assess. Surveys that are disaggregated across social groups may be used to identify which groups climate hazards affect most acutely. Qualitative methods like interviews and focus group discussions can give a rich picture of how diverse groups are affected by climate hazards; this can inform the design of responses that meet their needs. For example, focus group discussions and surveys were used in Burkina Faso to reveal that women of different ethnicities, living in the same region, were affected differently by climate impacts on water (one group of women suffered a greater burden of water-related labour, while the other suffered poorer water quality). Assessments should not just focus on people's disadvantages, but should identify the inherent capacities of marginalised people. People living on the forefront of climate risks hold important knowledge gained from their experiences, which they can share.

Social indicators of vulnerability, informed by thorough vulnerability assessments, can be used to map and monitor populations (for example, settlements, groups of people, districts) that are likely to be the most severely affected by climate hazards. Hundreds of social indicators have been proposed in a variety of contexts; they include indicators relating to income, literacy, migration status, ethnicity, age, gender and many more. Choice of indicators should be informed by the vulnerability assessment. Existing social data on household demographics and characteristics (for example, materials used for housing) can be used as data sources. Social indicators have been used to create social vulnerability maps in Brazil and Ivory Coast. However, social vulnerability is complex, and it can be difficult to monitor or assess vulnerability accurately with simplistic indicators.

The responses implemented when an indicator reaches a threshold should provide equitable benefits. That is, the responses need to be resourced so they cover any additional costs of reaching the most marginalised groups and improving their WASH access to match that of other households in their region. In addition to monitoring, vulnerability assessments can contribute to an understanding of how climate hazards affect people in different ways, and what solutions they require. These assessments can also be used to identify and acknowledge marginalised people's capacities and knowledge that can contribute to the design of solutions. Ideally, responses should be designed through inclusive processes and balance short-term needs, while positioning people to become more resilient over the long term.

Women participate in an impact diagram activity with researchers from UTS-ISF in Manggarai, Indonesia
Credit: UTS-ISF / Jeremy Kohlitz

Limits of an indicator approach

Indicators are useful in alerting WASH service authorities when emerging climate risks to WASH require attention, but they have limitations. Indicators work best when the risk or impact from a climate hazard is predictable. However, climate impacts never occur in isolation, and this can make indicators less accurate. For example, reduced rainfall can cause shortfalls in groundwater supplies, so rainfall rates can be an indicator. Simultaneously, other processes or actions, such as increased water demand or reduced groundwater recharge, can affect groundwater supplies. Indicators should be treated as alerts for attention, and more investigation may be needed to determine if responses are required.

Data availability for monitoring indicators is likely to be poor in many contexts. Advances in remote surveillance and other emerging methods will help. This learning resource outlines possible data sources in the Indicators for monitoring climate risks to WASH section and in Annex A. Cross-sectoral partnerships are also important for unlocking access to data sources. Many of the indicators presented in this document are of interest to other sectors as well. National platforms for collaboration on climate change may facilitate data sharing between sectors.

Social vulnerability strongly influences people's risk exposure and how they experience climate impacts. This learning resource does not provide guidance on vulnerability or resilience assessments, and moreover, indicators (even social indicators) are not a substitute for assessing levels of resilience or vulnerability, which require more in-depth investigation. Indicators should not be relied upon alone for assessing vulnerability or resilience, but used as one of several tools for providing insights.

It can be costly and time-consuming to monitor many local indicators, even if the data is already being collected by another agency for other purposes. WASH service authorities and supporting CSOs should aim to identify and monitor a manageable number of priority indicators using easily accessible data. Fewer indicators to monitor initially may be preferable, because national and subnational authorities may need time and resources to strengthen their monitoring capacity and develop systems for tracking and acting on indicators. In contexts with low data availability, cross-sectoral collaboration should be explored to unlock access to new data sources for WASH service authorities.

Men and women participate in community mapping exercises in Solomon Islands in separate groups   Credit: Solomon Islands National University

Indicators for monitoring climate risks to WASH

The indicators are categorised across six climate hazards: hydrological drought, extreme heat, flooding, extreme weather events, groundwater level rise, and sea level rise. Each climate hazard begins with an introduction to the hazard and its monitoring, a summary of the indicators, and a description of possible data sources or data collection methods for the indicators at global, national and subnational levels.

The following sections – for each climate hazard category outlined – include colour-coded tables that describe the key climate risks to WASH services, the corresponding indicators, and other pertinent information. Box 1 provides definitions of the key terms used in these sections.

Box 1. Definitions

Climate risk to WASH is a description of a key risk that the climate hazard poses for household WASH access and how it may disproportionately affect certain social groups. The risk may be categorised as involving water, sanitation, hygiene or all three.

Indicators, organised by the scale at which they are likely monitored – national, subnational or both, can be monitored to detect if a climate risk is likely to occur. Monitoring authorities can choose any combination of indicators that makes sense in the context.

Corresponding JMP indicator(s) that may be affected are indicators from the JMP core questions on water, sanitation and hygiene for household surveys (2018 update). If the climate risk occurs, the corresponding JMP indicators are at risk of being reduced, hence authorities may choose to monitor risks that pertain to key JMP indicators in their context.

Climate hazard(s) are the climate events or trends that drive the risk.

WASH modality refers to the type of WASH system or service that is most likely to be sensitive to the risk.

Example responses when threshold is reached are examples of how WASH authorities may respond when indicators suggest the risk level is high. These examples are illustrative and not comprehensive.

Key	Climate risk for WASH
	Risk to water
	Risk to sanitation
	Risk to hygiene
	Risk to all

Hydrological drought

A hydrological drought is a reduction in precipitation that leads to a shortfall in surface or subsurface water supplies. Droughts can reduce the availability of fresh water for drinking and domestic purposes, cause water-based sanitation infrastructure to fail, and limit the practice of handwashing.

Monitoring risks of hydrological drought involves monitoring a combination of indicators that depend on environmental conditions and the types of WASH technologies used in an area. For example, in areas where groundwater is primarily used for WASH, groundwater level is a pertinent indicator. In areas where surface water is used, river/streamflow is applicable.

The type of technology used also determines if a particular risk is relevant. For example, containment units that are designed to be desludged, but are not fully sealed, are at risk of drying out and becoming dysfunctional. Hence, this risk would be monitored in areas where this type of technology is prevalent.

Summary of all indicators for monitoring hydrological drought risks to WASH

- Number of days or months with below average rainfall
- Below average groundwater level (where groundwater is used)
- Percent of normal precipitation (surface water catchments)
- Reduced runoff or reduced river/streamflow
- Forecast standardized precipitation index (SPI)
- Combined drought indicator (CDI), Palmer drought severity index (PDSI), or effective drought index (EDI)
- Proportion of people dependent on rainwater, shallow groundwater or surface water for domestic uses
- Proportion of households without substantial storage containers (e.g., > 500 L) on site
- Key informant reports of people practising open defecation (OD) or using unsafe sanitation facilities when insufficient amounts of water are available for flushing toilets
- Proportion of people using containment units that are not fully sealed (e.g., bottomless septic tanks
- Proportion of households using small-bore (simplified) sewer systems

Data sources and methods

Global level

Many hydrological drought indicators are monitored remotely using satellite and remote sensing techniques. These techniques and data sources are expanding and improving rapidly, but can require sophisticated knowledge and interpretation skills. Notwithstanding, numerous international and national organisations use this data for localised interpretations. For example, the Flood and Drought Portal displays a spatial interpretation of Normalised Differential Vegetation Index (NDVI), EDI, CDI and other indicators at the global level. Further, the National Center for Atmospheric Research uses TERRA satellite data and the MODUS sensor to provide a gridded global evaluation of PDSI.

National level

Many countries have meteorological or climate services or departments that provide publicly available information, including with respect to the indicators mentioned here. Increasingly, these departments are extending their services from weather alone to forecasting and climate change effects. For example, the Fiji Bureau of Meteorology maps consecutive days without rain around many parts of the country and provides river hydrology information. The World Meteorological Organization (WMO) recommends the SDI for monitoring drought conditions, and many national organisations use it. For example, the Bangladesh Meteorological Department displays regular updates of the SDI and other drought monitoring indicators.

Subnational level

Precipitation and rainfall gauge data exists or can be established at subnational level in some countries, which can enable monitoring of precipitation trends. Further, precipitation data can be collected using citizen science techniques to reduce the monitoring burden on subnational governments, like was done across the United States under the Community Collaborative Rain, Hail and Snow network. Many cultures have a seasonal calendar (oral, visual or otherwise) that records indicators of the seasons, and in some cases, this extends to knowledge regarding impending weather events. For example, in some parts of India, drought conditions can be signalled by the flowering of bamboo trees or the failure of swallows to appear. These examples illustrate that on a subnational or project level, locally relevant indicators may be available based on a range of different knowledge systems.

Information about the types of WASH technologies used may be available in national census documents or surveys (for example, Demographic and Health Surveys (DHS) or Multiple Indicator Cluster Surveys (MICS)) or in local government records. If quantitative data on WASH technologies is not available, the tacit knowledge of local key informants (for example, local government staff) may be drawn on to determine if a high proportion of households use a particular WASH technology that is at risk or if few households store substantial amounts of water onsite.

A summary of example databases and data sources for each indicator is provided in Table 1 of Annex A.

Hydrological drought risks to monitor

Five examples of hydrological drought risks to household access to WASH (one for water, three for sanitation, and one for hygiene) are included. For most of the drought risks, the most appropriate indicator will depend on the water source (rainfall, surface water or groundwater) being used in the monitored area.

Climate risk for WASH	**Reduced availability of water for drinking:** water supplies dependent on seasonal rainfall become unreliable due to prolonged periods of reduced rainfall. Consequently, safe drinking water becomes unavailable and/or people must spend more time collecting water from alternative sources. Women and girls tasked with collecting and managing household water may be disproportionately burdened.
Indicators	**National:** 1. Forecast SPI, CDI, PDSI or EDI **Subnational:** 2. Reduced runoff or reduced river/streamflow 3. Proportion of households without substantial storage containers (e.g., > 500 L) on site 4. Below average groundwater level **National or subnational:** 5. Number of days or months with below average rainfall 6. Below average annual rainfall in surface water catchments 7. Proportion of people dependent on rainwater, shallow groundwater or surface water for domestic uses
Corresponding JMP indicator(s) that may be affected	W4. Time to collect drinking water W5. Availability of drinking water XW3. Burden of water collection XW5. Availability of water supply XW7. Continuity of water supply XW8. Discontinuity of water supply
Climate hazard(s)	Drought; changes in mean precipitation
WASH modality	Water supplies sensitive to changes in rainfall, such as rainwater harvesting systems and shallow springs and wells
Example responses when threshold is reached	• Deployment of packaged water to areas projected to be water stressed • Public warnings of water shortages and dissemination of advice on safely storing and rationing water • Inclusive development of new water supplies informed by the needs of women and girls

A WASH committee in Buka District, PNG, develop their Water Security Improvement Plan
Credit: Plan International

Climate risk for WASH	**Reduced availability of water for toilets:** reduced water availability leads to insufficient water for flushing. Consequently, water-based toilets cannot be operated and people may practise OD or use unsafe alternative sanitation facilities. Women and girls may be exposed to sexual harassment or violence while practising OD.
Indicators	**National:** 1. Forecast SPI, CDI, PDSI or EDI **Subnational:** 2. Below average groundwater level 3. Reduced runoff or reduced river/streamflow 4. Proportion of households without substantial storage containers (e.g., > 500 L) on site 5. Key informant reports of people practicing OD or using unsafe sanitation facilities when insufficient amounts of water are available for flushing toilets **National or subnational:** 6. Number of days or months with below average rainfall 7. Below average annual rainfall in surface water catchments 8. Proportion of people dependent on rainwater, shallow groundwater or surface water for domestic uses
Corresponding JMP indicator(s) that may be affected	S1. Sanitation facility XS3. Facility accessible to individual household members XS7. Privacy while using the facility
Climate hazard(s)	Drought; changes in mean precipitation
WASH modality	Sanitation facilities that use water for flushing
Example responses when threshold is reached	• Public warnings of water shortages and advice to store water for flushing • Deployment of emergency dry toilets (e.g., container-based toilets), particularly to vulnerable households, such as households with a family member with a disability • Preparation of communal toilets (in urban areas) for increased demand

Climate risk for WASH	**Dried faecal sludge cannot be removed:** faecal sludge inside onsite containment units hardens due to hot and dry conditions, and consequently cannot be emptied. Septic tanks with hardened content may need to be abandoned and low-income households may not be able to afford to replace them.
Indicators	**National:** 1. Forecast SPI, CDI, PDSI or EDI **Subnational:** 2. Below average groundwater level (subnational) 3. Reduced runoff or reduced river/streamflow (subnational) 4. Proportion of households without substantial storage containers (e.g., > 500 L) on site (subnational) 5. Proportion of people using containment units that are not fully sealed (e.g., bottomless septic tanks) (subnational) **National or subnational:** 6. Number of days or months with below average rainfall 7. Below average annual rainfall in surface water catchments 8. Proportion of people dependent on rainwater, shallow groundwater or surface water for domestic uses

Corresponding JMP indicator(s) that may be affected	XS12. Emptying of onsite facilities
Climate hazard(s)	Drought; extreme heat
WASH modality	Unsealed septic tanks or pits that require emptying, but allow liquids to infiltrate into the soil
Example responses when threshold is reached	• Desludging in areas where high proportions of households use unsealed septic tanks • Promotion of sealed septic tanks • Upgrading unsealed tanks to better containment units, with subsidised upgrading available for low-income households

Climate risk for WASH	**Blockage of sewers:** blockage and siltation of sewers and piping conveyance to onsite systems when water availability for conveyance of water through sewers/conveyance is reduced.
Indicators	**National:** 1. Forecast SPI, CDI, PDSI or EDI **Subnational:** 1. Below average groundwater level 2. Reduced runoff or reduced river/streamflow 3. Proportion of households without substantial storage containers (e.g., > 500 L) on site 4. Proportion of households using small-bore (simplified) sewer systems **National or subnational:** 5. Number of days or months with below average rainfall 6. Below average annual rainfall in surface water catchments 7. Proportion of people dependent on rainwater, shallow groundwater or surface water for domestic uses
Corresponding JMP indicator(s) that may be affected	XS9. Containment of wastes
Climate hazard(s)	Drought; changes in mean precipitation
WASH modality	Sewerage systems, including centralised and decentralised systems
Example responses when threshold is reached	Modify sewer design to function under reduced flowrates

Climate risk for WASH	**Reduced availability of water for hygiene:** insufficient amount of water leads to reduction in handwashing and personal hygiene, including menstrual hygiene.
Indicators	**National:** 1. Forecast SPI, CDI, PDSI or EDI **Subnational:** 2. Below average groundwater level 3. Reduced runoff or reduced river/streamflow 4. Proportion of households without substantial storage containers (e.g., > 500 L) on site **National or subnational:** 5. Number of days or months with below average rainfall 6. Below average annual rainfall in surface water catchments 7. Proportion of people dependent on rainwater, shallow groundwater or surface water for domestic uses
Corresponding JMP indicator(s) that may be affected	H2. Water observation
Climate hazard(s)	Drought
WASH modality	Handwashing facility
Example responses when threshold is reached	• Deployment of packaged water to areas projected to be water stressed • Public warnings of water shortages and dissemination of advice on safely storing and rationing water • Raising awareness on prioritising water for hygiene, including menstrual hygiene

Long Thanh Water Scheme - part of climate-resilient water safety planning in Vietnam, where access to water is under extreme threat from a growing population, increasing demands of agriculture and industry, and the worsening impacts of climate change, including drought and floods
Credit: Thrive Networks/East Meets West / Tran Tuan Anh

Extreme heat

Extreme heat refers to an episode of high air temperature that may be exacerbated by high humidity. For some WASH systems, increased temperatures can be beneficial (for example, by accelerating in-pit biological treatment for some sanitation options). However, particularly with respect to water sources and access, extreme heat can cause higher evaporative losses from surface water, expansion of and damage to pipes, and health harms when people are forced to collect water manually.

Monitoring risks of extreme heat involves forecasting heatwaves and high humidity, and monitoring areas where people fetch water from water sources that are likely to be affected by increased evaporation rates.

Summary of all indicators for monitoring extreme heat risks to WASH

- Forecast extreme heat and humidity
- Proportion of people collecting water from distant sources
- Proportion of households without substantial storage containers (e.g., > 500 L) on site
- Above average evaporation
- Reduced runoff or reduced river/streamflow

Women collect water during the dry season in Lao PDR — Credit: SNV / Bart Verweiji

Data sources and methods

Global level

Data related to temperature on a global scale is available and mapped at the Global Climate Monitor. The hazard levels related to extreme heat on a global scale but, disaggregated by country, is provided at ThinkHazard! The Emergency Events Database (EM-DAT) also holds a database of more than 22,000 disasters (including heat-related) globally from 1900 to the present day (The International Disasters Database). The World Bank Climate Change Knowledge Portal also provides temperature data for countries.

National level

National governments often issue alerts and warnings of forecast extreme heat or heat waves. Further, national meteorological services routinely issue temperature data that can be analysed for trends or annual number of extreme heat days. When assessing past or predicted extreme heat, the normal maximum temperature must be established (through assessment of the temperature record of a place), then daily temperature forecasts can be used to predict periods of extreme heat. Because extreme heat events have direct health impacts, ministries and departments of health commonly maintain data on heat-related health impacts that can be used to assess historical heat-related events.

Subnational level

District and provincial health departments can provide data on past heat-related health impacts that may indicate prevalence of heat-related health issues in an area. Local government agencies may have survey data about substantial household water storage containers (for example, those > 500 L). A summary of example databases and data sources for each indicator is provided in Table 2 of Annex A.

Extreme heat risks to monitor

Two WASH risks are listed below, one pertaining to water collection and one pertaining to water availability.

Climate risk for WASH	**Heat stress during water collection:** extreme heat and humidity make fetching water dangerous. Consequently, people suffer from heat-related illness or collect less water than needed. Women and girls are disproportionally affected in areas where they are primarily responsible for water collection.
Indicators	**National:** 1. Forecast extreme heat and humidity **Subnational:** 2. Proportion of people collecting water from distant sources 3. Proportion of households without substantial storage containers (e.g., > 500 L) on site
Corresponding JMP indicator(s) that may be affected	W5. Availability of drinking water XW3. Burden of water collection XW5. Availability of water supply XW8. Discontinuity of water supply
Climate hazard(s)	Extreme heat
WASH modality	Water points not on-premises
Example responses when threshold is reached	• Public warnings of forecast extreme heat and humidity, and advice to store water beforehand and conduct outdoor activities in early morning or late evenings • Distribution of packaged water • Inclusive development of new on-premises water supplies informed by the needs of women and girls

Climate risk for WASH	**Increased evaporation of surface water:** water supplies dependent on surface water become unreliable due to increased evaporation from extreme heat. Consequently, safe drinking water becomes unavailable and/or people must spend more time collecting water from alternative sources. Where women and girls are tasked with collecting and managing household water, they may be disproportionately burdened.
Indicators	**Subnational:** 1. Above average evaporation 2. Reduced runoff or reduced river/streamflow
Corresponding JMP indicator(s) that may be affected	W4. Time to collect drinking water W5. Availability of drinking water XW3. Burden of water collection XW5. Availability of water supply XW7. Continuity of water supply XW8. Discontinuity of water supply
Climate hazard(s)	Drought; changes in mean precipitation; extreme heat
WASH modality	Piped water from surface water sources
Example responses when threshold is reached	• Deployment of packaged water to areas projected to be water stressed • Public warnings of water shortages and dissemination of advice on safely storing and rationing water • Inclusive development of new water supplies informed by the needs of women and girls, and other vulnerable groups

Flooding

Flooding refers to water levels that are higher than normal, driven by intense or prolonged rainfall, river overflow and/or storm surges. Flooding may be extreme or low level (for example, waterlogging). Floods may develop slowly or rapidly. WASH infrastructure and services can be rendered inaccessible or inoperable by flood inundation, and the damage can mean re-establishment of treatment processes is slow. The severity of flood damage to centralised water and sanitation services and infrastructure tends to be strongly linked to the operation, management and governance of systems. Well-managed services maintain greater resilience, while onsite water and sanitation systems are affected differently depending on the specific infrastructure involved.

Floods typically occur and create impacts within a short period of time. Therefore, indicators of flood risk must trigger before the flood occurs (as opposed to droughts, which are slow developing and may be detected after they have begun). Monitoring risks of flooding to WASH involves forecasting heavy rainfall or floods, and the use or management of WASH technologies.

Summary of all indicators for monitoring risks of flooding to WASH

- Forecast pluvial and fluvial flooding
- Forecast heavy rainfall, especially following prolonged dry periods
- Forecast high tides combined with storm activity
- Number/proportion of unprotected springs/wells or water supplies without an implemented water safety plan (WSP)
- Proportion of rainwater harvesting systems without a first-flush device
- Roads/paths between communities and water sources becoming impassable when flooding occurs
- Availability of water storage containers at home
- Increased levels of E. Coli and/or other pathogen concentrations
- Proportion of sanitation facilities located in areas prone to storm surges or flooding
- Key informants (e.g., village leaders or local councillors) reporting the practice of deliberately opening treatment / containment units during flooding

Data sources and methods

Global level

Many websites provide global historic flood data. Two of the more useful open-source databases are the Global Flood Database and the Flood Mapping Tool. Using earth observation and remote sensing, historic floods have been mapped for many countries on both platforms, and thus can provide detailed spatial information showing flood extents. Proprietary flood mapping showing both historical and predicted extents can be accessed through multiple companies. Current flooding can be assessed using global databases, including the Global Facility for Disaster Reduction and Recovery's hazard mapping tool.

National level

Consistent with data sources for monitoring hydrological drought, many national departments of meteorology, environment, water, DRR or climate change provide national-level data for flood predictions, risk and warnings. These services can be accessed for data on precipitation data, forecast floods and precipitation, and warnings.

Subnational level

Flood mapping, particularly of high exposure and high population density (urban) areas, is becoming more common. For example, Port Moresby recently completed an urban development plan that included flood inundation mapping. This type of data may be accessible upon request from the relevant government departments. Sub-districts and local governments will likely be the most knowledgeable about, for example, at-risk infrastructure such as roads. Beyond government sources, flood exposure histories gleaned from local historical knowledge and residents' knowledge can be invaluable in a particular place, gathered through qualitative and quantitative data collection methodologies like surveys and interviews. Hazard maps may be generated by using historical data and local knowledge to map out areas known to be prone to flooding.

Information about the type of water supply used, whether a WSP has been implemented, the use of first-flush devices or water storage, and the location of sanitation technologies may be captured in existing national census or survey (for example, DHS or MICS) data, or documented by local government offices. Where quantitative data does not exist, the knowledge of local key informants (for example, local government staff) may be drawn on to assess prevalence of these indicators. Local knowledge (for example, from community leaders) may also be drawn on to assess whether people are likely to deliberately open containment units or if roads become impassable during flooding.

A summary of example databases and data sources for each indicator is provided in Table 3 of Annex A.

Flooding risks to monitor

Six climate risks for WASH (two for water, four for sanitation) are listed below. For water, these risks pertain to contamination and accessibility issues. For sanitation, they pertain to disruption of the functionality of sanitation technologies or emptying services, and faecal sludge management practices.

Climate risk for WASH	**Contamination:** water sources are contaminated by faecal pathogens from flooding and surface runoff. Consequently, people drink unsafe water or access more distant alternative sources. Low-income households that cannot afford or access packaged water or treatment technologies may be disproportionately affected.
Indicators	**National:** 1. Forecast heavy rainfall, especially following prolonged dry periods 2. Forecast high tides combined with storm activity **Subnational:** 3. Number/proportion of unprotected springs/wells or water supplies without an implemented Water Safety Plan 4. Proportion of rainwater harvesting systems without a first-flush device 5. Increased levels of E. Coli and/or other pathogen concentrations **National or subnational:** 6. Forecast pluvial and fluvial flooding
Corresponding JMP indicator(s) that may be affected	W6. Drinking water quality at the source XW1. Alternative water sources XW12. Drinking water quality in the household XW15. Acceptability of drinking water
Climate hazard(s)	Extreme precipitation; floods
WASH modality	All water supplies
Example responses when threshold is reached	• Public warnings to treat drinking water before consumption • Distribution of water treatment technologies and safe water storage receptacles to low-income households ahead of the wet season • Public advice to ensure water sources are properly sealed ahead of the wet season, and first-flush devices are used on rainwater harvesting systems

Climate risk for WASH	**Difficulty accessing water sources:** water sources become difficult to access due to heavy precipitation causing roads/paths to become impassable. Consequently, people spend more time collecting water. People with disabilities, elderly people, and pregnant women are likely to be disproportionately affected.
Indicators	**National:** 1. Forecast high tides combined with storm activity **Subnational:** 2. Areas where roads/paths between communities and water sources become impassable when flooding occurs 3. Availability of water storage containers at home **National or subnational:** 4. Forecast pluvial and fluvial flooding

Corresponding JMP indicator(s) that may be affected	W4. Time to collect drinking water
Climate hazard(s)	Extreme precipitation; floods
WASH modality	Communal water points not on-premises
Example responses when threshold is reached	• Public warnings to store water when heavy precipitation is forecast • Distribution of safe water storage receptacles ahead of the wet season, particularly to vulnerable households without an onsite source of water

Climate risk for WASH	**Toilets cannot function properly:** toilets cannot be used because seawater/floodwater causes backflow through outlets or inundates toilets. Consequently, people use unsafe alternative sanitation facilities or practise OD. Women and girls are subsequently exposed to harassment or sexual violence while using shared sanitation facilities or practising OD.
Indicators	**National:** 1. Forecast high tides combined with storm activity **Subnational:** 2. Proportion of sanitation facilities located in areas prone to storm surges or flooding **National or subnational:** 3. Forecast pluvial and fluvial flooding
Corresponding JMP indicator(s) that may be affected	S1. Sanitation facility XS3. Facility accessible to individual household members
Climate hazard(s)	Sea level rise; storm surges; floods
WASH modality	Onsite and decentralised sanitation facilities
Example responses when threshold is reached	• Preparation of communal toilets (in urban areas) for increased demand, including ensuring communal toilets have proper safety measures (toilets separated by gender, lockable doors, lighting, etc.) • Public advice to ensure manholes and other containment openings are sealed ahead of expected flooding

A farmer in Samroang Saean village, Cambodia, and her children stand by a latrine the family invested in through iDE's sanitation market. Behind them, watermarks left from the previous monsoon rain can be seen on the brick wall
Credit: Miguel Jerónimo Photography

Climate risk for WASH	**Containment and treatment technologies cannot function properly:** seawater/floodwater enters onsite treatment/containment units or soakpits and causes them to overflow. Consequently, faecal pathogens are spread to water and food sources and living environments. The subsequent health risks will likely be higher for low-income households living in dense settlements and using unimproved water supplies.
Indicators	**National:** 1. Forecast high tides combined with storm activity **Subnational:** 2. Proportion of sanitation facilities located in areas prone to storm surges or floods **National or subnational:** 3. Forecast pluvial and fluvial flooding
Corresponding JMP indicator(s) that may be affected	XS9. Containment of wastes XS10. Discharge of wastes from septic tanks
Climate hazard(s)	Sea level rise; storm surges; floods
WASH modality	Onsite and decentralised sanitation facilities
Example responses when threshold is reached	• Promote emptying services ahead of the wet season • Public advisories to avoid swimming or coming into contact with floodwater • Distribution of water treatment technologies to low-income households/communities likely to have their water sources affected

Climate risk for WASH	**Deliberate release of faecal waste by households:** people deliberately open onsite treatment/containment units to allow floodwater to wash out the contents. Consequently, faecal pathogens are spread to water and food sources and living environments. The subsequent health risks will likely be higher for low-income households living in dense settlements and using unimproved water supplies.
Indicators	**National:** 1. Forecast high tides combined with storm activity **Subnational:** 2. Key informants (e.g., village leaders or local councillors) reporting the practice of deliberately opening treatment / containment units during flooding 3. Proportion of sanitation facilities located in areas prone to storm surges or floods **National or subnational:** 4. Forecast pluvial and fluvial flooding
Corresponding JMP indicator(s) that may be affected	XS9. Containment of wastes
Climate hazard(s)	Floods; storm surges
WASH modality	Onsite sanitation facilities
Example responses when threshold is reached	• Raise public awareness on health risks of unsafe discharging of containment units • Promote safe emptying services

Climate risk for WASH	**Emptying services cannot reach households:** emptying services are unable to reach onsite containment units in need of desludging, or transport waste to treatment sites, due to flooded roads. Consequently, full containment units cannot be emptied or sludge is dumped onsite.
Indicators	**National:** 1. Forecast high tides combined with storm activity **Subnational:** 2. Proportion of sanitation facilities located in areas prone to flooding **National or subnational:** 3. Forecast pluvial and fluvial flooding
Corresponding JMP indicator(s) that may be affected	XS12. Emptying of onsite facilities
Climate hazard(s)	Floods
WASH modality	Onsite and decentralised sanitation facilities
Example responses when threshold is reached	Promote emptying services ahead of the wet season

Extreme weather events

Extreme weather events are acute events that cause physical damage or destruction of WASH infrastructure. They include cyclones, landslides, wildfires and floods. Flooding risks in this category are distinguished from those in the flooding category in being associated with physical damage or destruction of infrastructure rather than service disruptions due to inundation. Extreme weather events can be extremely disruptive to household WASH access, both in the short and long term, in particular where existing WASH access is poor or inadequate. Impacts include direct property loss and damage, as well as indirect damage that reduces household access, for example damage to and blocking of roads that can interrupt supply chains for bottled or tankered water, as well as tankered septage carting.

Monitoring the WASH risks of extreme weather events involves forecasting extreme weather events and monitoring the presence of WASH technologies that are sensitive and exposed to extreme weather. Extreme weather events must be detected before they occur, because their impacts (destruction of facilities) happen immediately.

Summary of all indicators for monitoring WASH risks of extreme weather events

- Tropical storm watch or warning, or tropical cyclone warning (or equivalent)
- Forecast floods
- Forecast high tides combined with storm activity
- Forecast fire weather
- Number/proportion of WASH facilities located in geographic areas prone to flooding, storm surges, wildfires or landslides
- Proportion of people using latrine superstructures constructed from weak materials (e.g., sheet metal or palm leaves)

Data sources and methods

Global level

The WMO is the lead international organisation under the United Nations framework responsible for the dissemination of weather, climate and water cycle information and the promotion of international cooperation for DRR. The WMO maintains a global, updated map of severe weather (including cyclone) warnings, which includes information on forecasts and ongoing events, contributing to early warning systems to support DRR. Identifying the extreme weather hazard levels for particular areas is possible through sites such as ThinkHazard!. Some national agencies provide data that is summarised at a global level; for example, the Japan Meteorological Agency displays heavy rain potential.

National level

Commonly, departments and ministries of meteorology and water resources provide severe weather forecasts and warnings. Early warning systems are a key focus of the Sendai Framework for Disaster Risk Reduction 2015-2030. Early warning systems (multi-hazard, but in particular for extreme weather events) allow for anticipatory actions for WASH, and can be used as part of an overall monitoring system for climate resilient WASH. For example, the Bangladesh Meteorological Department hosts a website that allows users to see current alerts (rain, wind, heat wave, cold wave and flash flooding), as well as view weather forecast maps and hazard calendars.

Subnational level

Provincial, district and local governments provide early warning, respond to, and assist communities to recover from extreme weather events. At this level, governments may be responsible for communicating and disseminating warnings to their communities, and may also hold knowledge of areas of particular hazard or risk. It is recognised, however, that inadequate resourcing (human, financial, material) often restricts local governments' ability to lead DRR. Humanitarian, non-governmental and community service organisations are typically active at the subnational level, and may hold knowledge and data at individual and organisational levels, or may coordinate within a cluster system. For example, in Vanuatu, the National Disaster Management Office links to all existing clusters, including WASH, and those collaborative spaces can be sources of information for predicted and historical extreme weather events on a subnational level.

The number/proportion of WASH facilities located in areas exposed to extreme weather may be determined from overlaying maps of extreme weather events (sometimes known as hazard maps) with GIS data on the locations of WASH facilities. The latter may be available from local government or non-governmental WASH or disaster agencies.

The proportion of people using latrine superstructures that are susceptible to damage from extreme weather events may exist in government surveys (for example, those that record the material used for superstructures), or local knowledge of key informants (for example, community leaders or local government officials).

A summary of example databases and data sources for each indicator is provided in Table 4 of Annex A.

People survey the devastation caused by Cyclone Fani in Tarini Basti, an informal settlement in Bhubaneswar, India
Credit: CFAR archives / Basudev Mahapatra

Extreme weather event risks to monitor

Two climate risks for WASH (one for all WASH facilities, one for sanitation) are listed below. These climate risks pertain to damage or destruction of extreme events to WASH facilities.

Climate risk for WASH	**Damage or destruction of WASH facilities:** damage to water supply, sanitation, and hygiene infrastructure from extreme weather-related events (floods, cyclones, landslides, etc.). Consequently, people cannot use or access a WASH facility. Women may be disproportionately affected if they are tasked with sourcing water for the family, and are more likely to experience violence, injury or death during and after a disaster.
Indicators	**National:** 1. Tropical storm watch or warning, or tropical cyclone warning (or equivalent) 2. Forecast floods 3. Forecast high tides combined with storm activity **Subnational:** 4. Proportion of people using latrine superstructures constructed from weak materials (e.g., sheet metal or palm leaves) **National or subnational:** 5. Forecast fire weather 6. Number/proportion of WASH facilities located in geographic areas prone to flooding, storm surges, wildfires or landslides
Corresponding JMP indicator(s) that may be affected	W1. Main drinking water source S1. Sanitation facility H1. Handwashing facility observation
Climate hazard(s)	Cyclones; floods; storm surges; high winds; landslides; wildfires
WASH modality	All, particularly WASH facilities with infrastructure above ground and built with weak materials (e.g., latrines superstructures built with sheet metal or palm leaves)
Example responses when threshold is reached	• Mobilise emergency response materials and staff to areas expected to be affected, including those skilled in handling gendered issues like gender-based violence • Emptying of containment units ahead of extreme weather event • Advice to communities to reinforce/anchor/secure WASH facilities

Climate risk for WASH	**Privacy issues due to damage to latrines:** Extreme weather events generate holes/cracks/openings in latrine superstructure, creating privacy and safety issues. These issues are likely to affect women and girls more acutely.
Indicators	**National:** 1. Tropical storm watch or warning, or tropical cyclone warning (or equivalent) 2. Forecast floods 3. Forecast high tides combined with storm activity **Subnational:** 4. Proportion of people using latrine superstructures constructed from weak materials (e.g., sheet metal or palm leaves) **National or subnational:** 5. Number/proportion of WASH facilities located in geographic areas prone to flooding, storm surges, wildfires or landslides

Corresponding JMP indicator(s) that may be affected	XS7. Privacy while using the facility XS8. Safety while using the facility
Climate hazard(s)	Flooding; cyclones; high winds; storm surges; wildfires; landslides
WASH modality	Latrine superstructures, especially those made from local or weak materials
Example responses when threshold is reached	Deployment of materials and staff for emergency repairs in anticipation of extreme weather-related events, including staff skilled in responding to issues of safety for women and girls

Groundwater level rise

Groundwater level rise refers to the water table coming closer to the surface, which can pose risks to underground water and sanitation infrastructure. Sea level rise, increased precipitation, and changes in precipitation patterns can contribute to groundwater level rise. As groundwater levels rise, the impact on sub-surface sanitation infrastructure can be significant. Pit latrines and unsealed septic tanks can be inundated, filling containment units and requiring more frequent pumping out.

Groundwater level is a key indicator of risk. Indicators of events that cause rises in groundwater can also be useful to monitor. As with other hazard risks, monitoring the presence of WASH technologies that are susceptible to damage or disruption from high groundwater levels is important.

Summary of all indicators for monitoring risks of groundwater level rise to WASH

- Heightened groundwater table
- Forecast sea level rise
- Forecast flooding
- Proportion of people using unlined pits
- Forecast above average rainfall in areas with high infiltration capacity (e.g., sandy soils)

Data sources and methods

Global level

Groundwater information is becoming increasingly available using remote sensing from space missions such as NASA's GRACE, which observes changes in the earth's gravity field, from which estimates of changes in water storages can be made. This information, and other useful groundwater information such as publicly available well monitoring data, is provided through the International Groundwater Resources Assessment Centre (IGRAC).

National level

Some countries monitor centralised well networks manually or through telemetry, and may provide data through public platforms or on request. For example, both Nepal and India publish data through national departments. IGRAC also provides regular reviews of national monitoring programs with links to relevant sources and products.

Subnational level

In some regions where groundwater is used, subnational governments and local authorities monitor groundwater wells and thus can provide monitoring data. Citizen science monitoring programs have been tested in some locations, such as Nepal, where citizen well monitoring has proved to be an economic and sustainable approach to data collection.

Maps of areas with high infiltration capacity (the rate at which soil absorbs water) may be available from government or non-governmental environmental or geological agencies. Hydrogeological surveys can provide information on areas likely to have high infiltration capacity.

Information on the proportion of people using unlined pits may be available from subnational surveys or the local knowledge of key informants (for example, community leaders or local government officials).

A summary of example databases and data sources for each indicator is provided in Table 5 of Annex A.

Groundwater level rise risks to monitor

Three climate risks for WASH (one for water, two for sanitation) are listed below. The risks pertain to damage to WASH infrastructure as a result of being exposed to high groundwater tables.

Climate risk for WASH	**Damage to water pipes:** water pipes are damaged by corrosion, stress from floatation, and expansion/contraction of soils due to rising groundwater levels. Consequently, pipes leak and reduce pressure in systems or allow contaminants to infiltrate.
Indicators	**National:** 1. Forecast sea level rise **Subnational:** 2. Heightened groundwater table
Corresponding JMP indicator(s) that may be affected	W5. Availability of drinking water W6. Drinking water quality at the source XW5. Availability of water supply XW12. Drinking water quality in the household XW15. Acceptability of drinking water
Climate hazard(s)	Sea level rise; floods; changes in mean precipitation
WASH modality	Piped networks
Example responses when threshold is reached	Construct or retrofit piped networks with flexible and/or robust materials

A sanitation business labourer installs an iDE-designed latrine upgrade to maintain toilet functionality in high groundwater and dense, saturated soil. He adds gravel to the leach field to provide preliminary treatment of the wastewater and increase surface area for improved infiltration
Credit: iDE Cambodia / Kim Heng Lay

Climate risk for WASH	**Pit collapse:** pit collapse due to high groundwater level or flooding can injure the person using the toilet. Pit collapse may force people to use alternative, unsafe sanitation facilities or practise OD. Children and elderly people may be at higher risk of injury due to pit collapse.
Indicators	**National:** 1. Forecast sea level rise **Subnational:** 2. Heightened groundwater table 3. Proportion of people using unlined pits **National or subnational:** 4. Forecast flooding
Corresponding JMP indicator(s) that may be affected	S1. Sanitation facility XS8. Safety while using the facility
Climate hazard(s)	Floods; above average rainfall
WASH modality	Pit latrines
Example responses when threshold is reached	Promote the lining of pits in areas prone to flooding or with high groundwater tables

Climate risk for WASH	**Containment or treatment technologies cannot function properly:** high groundwater level causes onsite treatment/containment units or soakpits to overflow and/or float. Consequently, treatment/containment units malfunction or release pathogens into water and food sources and living environments. The subsequent health risks will likely be higher for low-income households living in dense settlements and using unimproved water supplies.
Indicators	**National:** 1. Forecast sea level rise 2. Forecast above average rainfall in areas with high infiltration capacity (e.g., sandy soils) **Subnational:** 3. Heightened groundwater table
Corresponding JMP indicator(s) that may be affected	XS9. Containment of wastes XS10. Discharge of wastes from septic tanks
Climate hazard(s)	Sea level rise; floods; above average rainfall
WASH modality	Onsite and decentralised sanitation facilities
Example responses when threshold is reached	• Develop plans for raised sanitation facilities • Distribution of water treatment technologies to low-income households/communities likely to have their water sources affected

Sea level rise

Sea level rise refers to a change in the mean sea surface height relative to the land in a local area. Sea level rise risks in this category include risks that are not already covered in other categories, including the risks posed from coastal erosion and storm surges. Both of these events can cause direct damage to infrastructure, and other disruptions and loss such as corrosion, inundation and undercutting of toilet pits.

Monitoring risks of sea level rise involves directly monitoring relative sea level over time, as well as signs that saltwater is beginning to intrude into freshwater. Indicators of WASH facilities exposed to saltwater intrusion, and backup options, are also needed.

Summary of all indicators for monitoring WASH risks of sea level rise

- Forecast mean sea level rise
- Proportion of WASH infrastructure located in coastal areas exposed to sea level rise
- Raised groundwater electrical conductivity levels
- Community reports of salty tasting water
- Availability of safe backup water supplies

Data sources and methods

Global level

Remote satellite monitoring can provide very accurate measurement of sea levels over time. Such monitoring can provide informative trend data. Predicted areas of sea level rise across the globe can be visualised at Climate Central, where users can view land below sea level rise scenarios (in height) at various degrees of expected warming.

National level

Real-time storm surge heights are provided at a national level by some meteorological and environmental departments (for example, in Bangladesh). The World Bank Climate Change Knowledge Portal provides country profiles with extensive information on climate change vulnerabilities and hazards, including sea level rise.

Subnational level

Local authorities and communities can use tide gauges to provide real-time data about sea levels. Tide gauges worldwide are listed at the UNESCO Sea Level Station Monitoring Facility. Local knowledge of sea level changes is highly valuable for local interventions. Some countries have established environmental rangers programs, supported by NGOs and local authorities, which monitor land and sea conditions. These programs collect sea level data in places such as Solomon Islands, Papua New Guinea, and Australia's Torres Strait Islands.

A summary of example databases and data sources for each indicator is provided in Table 6 of Annex A.

Sea level rise risks to monitor

Two climate risks for WASH (one for all WASH facilities, one for water) are listed. They pertain to damage to infrastructure from erosion and salinisation of drinking water sources.

Climate risk for WASH	**Damage to WASH facilities from erosion:** sea level rise can increase coastal erosion and thereby damage WASH infrastructure. Low-income households and communities may struggle to replace WASH assets.
Indicators	**National:** 1. Forecast mean sea level rise **Subnational:** 2. Proportion of WASH infrastructure located in coastal areas exposed to sea level rise
Corresponding JMP indicator(s) that may be affected	W1. Main drinking water source S1. Sanitation facility H1. Handwashing facility observation
Climate hazard(s)	Sea level rise; storm surges
WASH modality	All, particularly WASH facilities built on soil that is sensitive to erosion (e.g., sandy soils)
Example responses when threshold is reached	• Relocation of WASH infrastructure, informed by the needs of vulnerable groups to ensure new WASH facilities meet their needs • Construction of seawalls or other erosion barriers

Climate risk for WASH	**Salinisation of groundwater sources:** Saltwater intrudes into groundwater sources used for drinking. Consequently, safe or acceptable drinking water becomes unavailable and/or people must spend more time collecting water from alternative sources. Women and girls tasked with collecting and managing household water may be disproportionately burdened.
Indicators	**Subnational:** 1. Raised groundwater electroconductivity levels 2. Community reports of salty tasting water 3. Availability of safe backup water supplies
Corresponding JMP indicator(s) that may be affected	W4. Time to collect drinking water W6. Drinking water quality at the source XW15. Acceptability of drinking water
Climate hazard(s)	Sea level rise; storm surge
WASH modality	Groundwater supplies in close proximity to the sea or brackish water bodies
Example responses when threshold is reached	• Water demand management interventions to manage the abstraction/recharge of groundwater • Drilling of new wells/boreholes in aquifers less exposed to saltwater intrusion

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wfw.fund/CC-Indicators-survey

Annex A. Indicator data sources

Table 1. Hydrological drought data sources

Indicator	Example dataset	Further reading
Number of days or months with no or below average rainfall	**Global** AQUASTAT Climate Information Tool: https://aquastat.fao.org/climate-information-tool/ **Pacific** Pacific Climate Change Data Portal (bom.gov.au): http://www.bom.gov.au/climate/pccsp/ **United States** Condition Monitoring (cocorahs.org): https://www.cocorahs.org/Maps/conditionmonitoring/	Tools and resources for planning ahead – Regional Climate Consortium for Asia and the Pacific: https://www.rccap.org/pacific-guidance-and-case-studies/tools-and-resources-for-planning-ahead/
Below average groundwater level	**Global** Global Groundwater Information System (GGIS), International Groundwater Resources Assessment Centre (unigrac.org): https://www.un-igrac.org/global-groundwater-information-system-ggis **Thailand** Department of Groundwater Resources (dgr.go.th): http://tgms.dgr.go.th/#/home **India** India Water Resources Information System: https://indiawris.gov.in/wris/#/groundWater	National groundwater monitoring programmes - A global overview of quantitative groundwater monitoring networks - 2021 update: https://www.un-igrac.org/sites/default/files/resources/files/National%20groundwater%20monitoring%20programmes%20-%20A%20global%20overview%20of%20quantitative%20groundwater%20monitoring%20networks-2021%20update_0.pdf
Reduced runoff or reduced river/ streamflow	**Fiji** Live river level monitoring https://www.met.gov.fj/RiverLevel.html **Canada** Modelled Streamflow Data (pacificclimate.org): https://data.pacificclimate.org/portal/hydro_stn_cmip5/map/	
Percent of normal precipitation below average annual rainfall (in surface water catchments)	Can calculate from rainfall records – best to use at least 30 years of data **Samoa** Rainfall Status Map (samet.gov.ws): http://www.samet.gov.ws/index.php/rainfall-status	Handbook of Drought Indicators and Indices: https://www.drought.gov/sites/default/files/2020-06/GWP_Handbook_of_Drought_Indicators_and_Indices_2016.pdf NDVI Map Information (bom.gov.au): http://www.bom.gov.au/climate/austmaps/about-ndvi-maps.shtml
Forecast SPI	**Bangladesh** SPI for One Month - Bangladesh Meteorological Department (bmd.gov.bd): http://live4.bmd.gov.bd/p/One-Month	
Normalised Differential Vegetation Index (NDVI)	**Australia** Climate Maps - NDVI Archive (bom.gov.au): http://www.bom.gov.au/jsp/awap/ndvi/index.jsp	

<table>
<tr><td>CDI, PDSI, or EDI</td><td>Global

Flood and Drought Portal (flooddroughtmonitor.com): https://www.flooddroughtmonitor.com/home?showLogin=true&redirect=data</td><td></td></tr>
<tr><td>Proportion of people dependent on rainwater, shallow groundwater or surface water for drinking</td><td>JMP (washdata.org) for national level: https://washdata.org/

National census, MICS or DHS surveys - request enumeration area data from statistics departments for local area data</td><td></td></tr>
<tr><td>Proportion of households without substantial storage containers (e.g., > 500 L) on site</td><td rowspan="4">Household surveys and sanitary inspections

Data from service authorities or service providers

Contact WASH clusters or sector groups for existing data

JMP (washdata.org) for national level: https://washdata.org/

National census, MICS or DHS surveys - request enumeration area data from statistics departments</td><td rowspan="4">Guidance on Monitoring Safely Managed Sanitation - JMP 2022 (washdata.org): https://washdata.org/sites/default/files/2022-08/jmp-2022-smoss-monitoring-guidance-august-2022_0.pdf</td></tr>
<tr><td>Key informant reports of people practicing OD or using unsafe sanitation facilities when insufficient amounts of water are available for flushing toilets</td></tr>
<tr><td>Proportion of people using containment units that are not fully sealed (e.g., bottomless septic tanks</td></tr>
<tr><td>Proportion of households using small-bore (simplified) sewer systems</td></tr>
</table>

Table 2. Extreme heat data sources

Indicator	Example dataset	Further reading
Forecast (projected) extreme heat and humidity	**Global** Global Climate Monitor: https://www.globalclimatemonitor.org/ **National example – United States:** Future Heat Events and Social Vulnerability 2018 (esri.com): https://geoxc-apps2.bd.esri.com/Climate/HeatVulnerability/index.html	Extreme heat: A media resource guide - National Oceanic and Atmospheric Administration (noaa.gov): https://www.noaa.gov/media-advisory/extreme-heat-media-resource-guide
Annual number of extreme heat days within a period	As above	
Historic heatwave extents	EM-DAT - The International Disasters Database (emdat.be): https://www.emdat.be/	
Extreme heat hazard level	ThinkHazard! https://thinkhazard.org/en/	
Average temperature anomalies	Global Climate Monitor: https://www.globalclimatemonitor.org/	
Proportion of people collecting water from distant sources	Refer to Table 1 for WASH data sources	
Proportion of households without substantial storage containers (e.g., > 500 L) on site		
Above average evaporation	In-field monitoring **National** Water and the Land: Evaporation (bom.gov.au) : http://www.bom.gov.au/watl/evaporation/	

Table 3. Flood data sources

Indicator	Example dataset	Further reading
Forecast or current flooding extent	**Global** Flood and Drought Portal (flooddroughtmonitor.com): https://www.flooddroughtmonitor.com/ The Flood Observatory (colorado.edu): https://floodobservatory.colorado.edu/index.html	
Forecast heavy rainfall, especially following prolonged dry periods	**Global** Japan Meteorological Agency - Heavy Rain Potential (jma.go.jp): https://www.data.jma.go.jp/omaad/rsmc_nowcast/en/hrp/#zoom:5/lat:12.961736/lon:107.204590/colordepth:normal/elements:hrp	
Forecast high tides combined with storm activity (extent)	**Bangladesh** Bangladesh Meteorological Department – Storm Surge: http://live4.bmd.gov.bd/p/Storm-Surge	
Precipitation trends – number of days of rain	National bureaus of meteorology	
Historic flood event extent	**Asia** DFO: Asia Flood information (colorado.edu): https://diluvium.colorado.edu/arcgis/apps/Viewer/index.html?appid=508e429fc82443098bc087f00cd7fa77	
Flood hazard level	ThinkHazard! www.thinkhazard.org	
Number/proportion of unprotected springs/wells or water supplies without an implemented WSP	Department responsible for water safety planning (e.g., Ministry of Health, Department of Water Resources, etc).	
Proportion of rainwater harvesting systems without a first-flush device	Community surveys Infrastructure inspections	
Roads/paths between communities and water sources that become impassable when heavy precipitation occurs	Local government mapping Community knowledge	
Availability of water storage containers at home	JMP (washdata.org) for national level: https://washdata.org/ National census, MICS or DHS surveys - request enumeration area data from statistics departments	
Increased levels of E. Coli and/or other pathogen concentrations	Local government monitoring programs Department of environment monitoring programs	
Proportion of sanitation facilities located in areas prone to storm surges or flooding	Household surveys and sanitary inspections Data from service authorities or service providers Contact WASH clusters or sector groups for existing data JMP (washdata.org) for national level: https://washdata.org/	Guidance on Monitoring Safely Managed Sanitation - JMP 2022 (washdata.org): https://washdata.org/sites/default/files/2022-08/jmp-2022-smoss-monitoring-guidance-august-2022_0.pdf
Key informants (e.g., village leaders or local councillors) reporting the practice of deliberately opening treatment / containment units during flooding	Community interviews Household surveys	

Table 4. Extreme weather data sources

Indicator	Example dataset	Further reading
Tropical storm watch or warning, or tropical cyclone warning (or equivalent)	**Global** Severe Weather Information Centre 2.0 (wmo.int): https://severeweather.wmo.int/v2/ **Regional** Southern Hemisphere Tropical Cyclone Data Portal (bom.gov.au) http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/tracks/	
Forecast floods	Refer to Table 3	
Forecast high tides combined with storm activity	Refer to Table 6	
Forecast fire weather	**Global** ECMWF - CAMS Global Fire Assimilation System: https://apps.ecmwf.int/datasets/data/cams-gfas/	Impact of wildfires in Asia - Copernicus: https://www.copernicus.eu/en/use-cases/impact-wildfires-asia
Hazard level or past events (flood, cyclone, tsunami, landslip, wildfire)	ThinkHazard! www.thinkhazard.org ASEAN Disaster Information Network (ahacentre.org): https://adinet.ahacentre.org/	
Number/proportion of WASH facilities located in areas prone to flooding, storm surges, wildfires or landslides	Household surveys and sanitary inspections Data from service authorities or service providers Contact WASH clusters or sector groups for existing data JMP (washdata.org) for national level: https://washdata.org/	Guidance on Monitoring Safely Managed Sanitation - JMP 2022 (washdata.org): https://washdata.org/sites/default/files/2022-08/jmp-2022-smoss-monitoring-guidance-august-2022_0.pdf
Proportion of people using latrine superstructures constructed from weak materials (e.g., sheet metal or palm leaves).	Household surveys and sanitary inspections	

Table 5: Groundwater data sources

Indicator	Example dataset	Further reading
Heightened groundwater table	**Global** Global Groundwater Information System (GGIS) International Groundwater Resources Assessment Centre (un-igrac.org): https://www.un-igrac.org/global-groundwater-information-system-ggis AQUASTAT - FAO's Global Information System on Water and Agriculture: https://www.fao.org/aquastat/en/ **Thailand** Department of Groundwater Resources (dgr.go.th): http://tgms.dgr.go.th/#/home **India** India Water Resources Information System, India-WRIS (indiawris.gov.in): https://indiawris.gov.in/wris/#/groundWater	National groundwater monitoring programmes - A global overview of quantitative groundwater monitoring networks - 2021 update (un-igrac.org): https://www.un-igrac.org/sites/default/files/resources/files/National%20groundwater%20monitoring%20programmes%20-%20A%20global%20overview%20of%20quantitative%20groundwater%20monitoring%20networks-2021%20update_0.pdf
Forecast sea level rise	Refer to Table 6	
Forecast floods	Refer to Table 3	
Proportion of people using unlined pit toilets	Household surveys and sanitary inspections Data from service authorities or service providers Contact WASH clusters or sector groups for existing data JMP (washdata.org) for national level: https://washdata.org/	Guidance on Monitoring Safely Managed Sanitation - JMP 2022 (washdata.org): https://washdata.org/sites/default/files/2022-08/jmp-2022-smoss-monitoring-guidance-august-2022_0.pdf
Forecast above average rainfall in areas with high infiltration capacity (e.g., sandy soils)	Refer to Table 3	

Table 6. Sea level rise data sources

Indicator	Example dataset	Further reading
Forecast mean sea level rise	**Global** Dataset Record: ESA Sea Level Climate Change Initiative (Sea_Level_cci): Oceanic Indicators of Mean Sea Level Changes, Version 2.0 (ceda.ac.uk): https://catalogue.ceda.ac.uk/uuid/3ac333b828b54e3495c7749f5bce2fe3 World Bank (data for each country) - Climate Change Knowledge Portal (worldbank.org): https://climateknowledgeportal.worldbank.org/ **Regional** Pacific Sea Level Monitoring Project (bom.gov.au): http://www.bom.gov.au/pacific/projects/pslm/ **National** Sea Level Prediction for Samoa (samet.gov.ws): http://www.samet.gov.ws/index.php/clews-products/sea-level-prediction-for-samoa	
Ongoing storm surge heights	**Global** GSSR - a global storm surge database: http://gssr.info/ **National - Bangladesh** Bangladesh Meteorological Department – Storm Surge (bmd.gov.bd): http://live4.bmd.gov.bd/p/Storm-Surge Tide gauge monitoring networks	A database of global storm surge reconstructions-Scientific Data (nature.com): https://www.nature.com/articles/s41597-021-00906-x
Proportion of coastal land at or below sea level	**Global** Google-based mapping of all land below certain elevations https://coastal.climatecentral.org/ National governments likely to hold data	
Proportion of WASH infrastructure located in coastal areas exposed to sea level rise	Household surveys and sanitary inspections Data from service authorities or service providers Contact WASH clusters or sector groups for existing data JMP (washdata.org) for national level: https://washdata.org/	Guidance on Monitoring Safely Managed Sanitation - JMP 2022 (washdata.org): https://washdata.org/sites/default/files/2022-08/jmp-2022-smoss-monitoring-guidance-august-2022_0.pdf
Raised groundwater electrical conductivity levels	Local government monitoring programs Department of environment monitoring programs	
Community reports of salty tasting water	Household surveys and interviews	

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