TOOLS & METHODS

WASH Services and Climate Change

Impacts and Responses

pS-Eau
programme Solidarité-Eau

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List of Acronyms

CH_4	Methane
CO_2	Carbon Dioxide
COP	Conference of the Parties (see p.10.)
GHG	Greenhouse gas
H_2S	Hydrogen Sulphide
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous Oxide
NDC	Nationally Determined Contribution: climate actions submitted by countries as part of the Paris Climate Agreement
NGO	Non-Governmental Organisation
SDG	Sustainable Development Goal
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organisation

Note: *This guide draws on and summarises literature and research on climate change, water resource management and water and sanitation services. To facilitate understanding and knowledge-sharing, some of the terms and definitions identified in the literature review have been simplified. Should you wish to further explore any of the topics covered in this guide, all the references used are listed in the Appendices.*

The definitions of the terms highlighted in orange are provided in the Glossary contained in Appendix 3.

Foreword

With a growing number of countries being affected by rising sea levels, more frequent cyclones or longer droughts, climate change is now recognised as the major challenge of this century for humanity. The impacts of the rise in global temperatures on the large water cycle are both well known and well documented. Since the 1990s, these impacts have been scientifically substantiated in the reports published by the Intergovernmental Panel on Climate Change (IPCC): warming of the oceans, glacier melt, rising sea levels, extreme weather events leading to successive droughts and floods, and so on.

The impacts on water resources also have repercussions for the availability and continuity of water and sanitation services. The effects of climate change, together with population growth and urbanisation, have major health, social and economic impacts. These impacts can be seen across the world but particularly affect the most vulnerable communities, thereby exacerbating inequalities. In sub-Saharan Africa, access to drinking water and sanitation is already being significantly affected by droughts and water scarcity.

Adapting to climate change is crucial for basic services, which are especially vulnerable to climate-related hazards. Efforts to mitigate global warming can and should also be introduced. However, decision-makers and field practitioners struggle to fully adopt these approaches, which involve conducting forecasting exercises made difficult by uncertainties over future climate change scenarios and the unpredictability of climate-related hazards. It is therefore necessary for all stakeholders to build a better understanding of these risks and to take steps to change and adapt their practices in the field.

The aim of this guide is to provide an insight into **understanding the impacts of climate change on WASH services** and to propose **operational courses of action for climate change adaptation and mitigation for services in developing countries.** It is intended for all water, sanitation and international solidarity stakeholders, all of whom are affected by this issue.

Although this guide mainly focuses on water and sanitation services, it also addresses broader considerations related to other basic services, such as water resources management and stormwater management.

1. Background and Climate Change Issues

Climate change, a global issue

Climate change is defined as a long-term change in the earth's overall climate or in its various regional climates. These changes can be caused by processes inherent to the earth (solar activity, volcanoes, etc.), to the biosphere or to human activity. The changes currently taking place are mainly attributed to the human production of greenhouse gases, which include carbon dioxide (CO_2) and methane (CH_4), and which result in the warming of the atmosphere.

The impacts of global warming can be seen on different scales in all areas of the world. They affect both the environment and human societies at all levels (local, national, regional and global). Thus, the global rise in sea levels poses a threat to people and ecosystems in coastal areas. At the local level, droughts and heatwaves create an increased risk of water shortages. Heavy rainfall that leads to flooding can cause severe damage in urban areas and directly put people's lives at risk.

Climate change exacerbates existing vulnerabilities caused by other human-induced phenomena, such as population growth, urbanisation, and changes in farming or industrial practices.

Nowhere is immune to climate change and the multiple risks that can arise out of the same climate-related hazard need to be **addressed using systemic approaches.** The action to be taken should be defined not only for the local level, but also for countries and regions, and all relevant stakeholders need to be involved. Despite the increasingly pressing need to take action, this also provides an opportunity to review our practices and lifestyles and to adopt more sustainable, appropriate and inclusive approaches.

A **systemic approach** adopts an overall approach to addressing problems or systems by examining and focusing on the interplay between their various elements.

Source: IAU – ARENE (2018)

International agreements and frameworks

At the global level, knowledge on climate change and its impacts is monitored by the **Intergovernmental Panel on Climate Change** (IPCC), which was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Thousands of scientists voluntarily contribute to the work of the IPCC in order to provide it with up-to-date scientific, technical and socio-economic knowledge on climate change. Five evaluation reports have been published to date, the fifth of which was issued in 2014, and the next report is scheduled for 2022. The IPCC also publishes special interim reports.

There are a number of international events and agreements that draw on the work of the IPCC and combine to form a climate action framework:

The COP and the Paris Climate Agreement

The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 at the Rio Earth Summit. The countries that signed this convention meet each year at the annual Conference of the Parties (COP) to this Convention to negotiate the international rules and conditions required to tackle climate change and its impacts.

At COP 21 in Paris in 2015, the Parties reached a historic agreement to tackle and adapt to climate change, known as the Paris Agreement. This agreement was adopted on 4 November 2016. In 2018, it was ratified by 181 of the 197 countries that are party to the Convention.

The key aim of the Paris Agreement is to "hold the increase in the global average temperature to well below 2°C above pre-industrial levels" and, if possible, to "pursue efforts to limit the temperature increase to 1.5°C" by the end of the 21st century.

The Paris Agreement also included an overall climate change adaptation objective to strengthen the resilience of both people and ecosystems. It notably encourages countries to significantly ramp up their national adaptation efforts and underlines the need to provide greater support to developing countries. For the first time, adaptation is now recognised as a major global issue, alongside mitigation.

To achieve these two objectives, the Paris Agreement requires all Parties to submit 'Nationally Determined Contributions' (NDCs), in which each country sets out its national mitigation and adaptation commitments. Countries are encouraged to submit updated and more ambitious contributions every five years. A global review will also be carried out every five years to assess the collective progress made towards achieving the Paris Agreement's objectives from 2023 onwards.

In 2016, 93% of the NDCs received included an adaptation component that made reference to water[1]. Drinking water was one of the four priorities mentioned, along with agricultural water, drought and flood risk management, and integrated water resources management.

The Paris Agreement also reiterated the commitment made by developed countries in Copenhagen in 2009 to provide US$100 billion each year up to 2020 to help developing countries tackle climate change.

The **resilience** of social, economic, and environmental systems defines their capacity to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and transformation.

Source : IPCC, 2014

1. Source: Partenariat Français pour l'Eau and Coalition Eau (2016). *Review of the Integration of Water within the Intended Nationally Determined Contributions* (INDCs) for COP21.

Agenda 2030 and its Sustainable Development Goals

The sustainable development programme adopted by the United Nations for the period 2015–2030 sets out a global framework for action and global goals for ending extreme poverty and fighting inequalities and injustice, in line with sustainable development principles. **This new global framework for action, also known as Agenda 2030, contains 17 Sustainable Development Goals** (SDGs), which are broken down into 169 specific targets and 232 monitoring indicators.

One of these goals, SDG 6, focuses specifically on all aspects of water, sanitation and hygiene. SDG 13 covers measures to tackle climate change.

SDG 6 – Ensure availability and sustainable management of water and sanitation for all
SDG 13 – Take urgent action to combat climate change and its impacts

The IPCC Special Report on Global Warming of 1.5°C[2] reiterates that "climate change impacts and responses are closely linked to sustainable development which balances social well-being, economic prosperity and environmental protection".

In 2015[3]:

Nearly **30%** of the global population did not have access to a safely managed drinking water service, that is, one located on premises, available when needed and free from contamination.

More than **60%** of the global population did not use a safely managed sanitation service, that is, excreta safely disposed of in situ or treated off-site.

2. Source: IPCC (2018) *Special Report on Global Warming of 1.5 °C*
3. Source: JMP (2017) *Progress on Drinking Water, Sanitation and Hygiene: 2017* Update and SDG Baselines

The Sendai Framework

The **Sendai Framework for Disaster Risk Reduction 2015–2030** sets out a global approach to developing disaster risk reduction policies. Adopted by UN member states in 2015 at the United Nations World Conference on Disaster Risk Reduction in Sendai in Japan, this framework replaces the Hyogo Framework for Action 2005–2015. The framework contains seven targets and associated indicators. Water and sanitation services are covered in Target D:

> **Target D** – Substantially reduce disaster damage to critical infrastructure and disruption of basic services […] including through developing their **resilience**.

Solidarity, an important driver of climate action

The essential role of international cooperation as a key factor in helping developing countries and the world's most vulnerable regions adapt to climate change was highlighted in the IPCC's Special Report on Global Warming of 1.5°C.

A country's level of development is a marker of its vulnerability: the greatest impacts are felt in the least developed countries and affect the most vulnerable communities. Therefore, improving universal access to WASH services and protecting water resources helps to reduce people's vulnerability and dampen the impacts of the climate-related hazards that occur. International cooperation thus has a vital role to play in tackling climate change:

- **Building the capacities of local stakeholders** (governance, local public service management) through institutional and technical cooperation, especially as part of resource management initiatives (river basin planning). These partnerships are useful for comparing, and thus reviewing, the practices employed in both the Global North and South;
- **Involving local stakeholders:** making use of local skills and resources in the Global North and South (NGOs and associations, diaspora, service operators, businesses);
- **Educating and raising the awareness of civil society stakeholders** on solidarity and tackling the impacts of climate change through cooperation projects;
- **Providing financial assistance** to support action in the various countries and leverage further funding.

The challenges for water supply and sanitation services

When faced with climate change, it becomes increasingly difficult for services to adapt to the growing needs of users and help with the important task of protecting resources and natural environments.

Water and sanitation services are particularly vulnerable:

- They rely on water resources, themselves severely impacted by climate change, being available and of good quality;
- Global warming and climate-related hazards have impacts that can adversely affect the operation of services and their long-term viability.

At the same time, the activities involved in operating water supply and, in particular, sanitation services can produce greenhouse gases and thus contribute to global warming. Although not among the highest emitting sectors, especially when compared with industrial sectors, for example, it is nevertheless important to highlight the ways in which water and sanitation services can be a source of greenhouse gas emissions.

Water and sanitation sector stakeholders today face a range of challenges:

- On the one hand, **they need to improve their understanding of the impacts of climate-related hazards on services** in order to better identify the vulnerability of their service area. → Chapter 2
- On the other, they need **to acquire the resources required to respond to these risks**, relative to the scale of the impacts and despite the uncertainties inherent in future global warming scenarios. Climate change adaptation and mitigation should be included in strategies and interventions and enable synergies between sectors. → Chapter 3

Urgent responses to accelerating climate change

In 2017, global warming had already reached 1°C above pre-industrial levels (with a measurement uncertainty of 0.2°C), indicating the urgency of the climate issue. Regardless of the scale of future emissions, the impact of past emissions will be felt for hundreds, if not thousands, of years and will continue to create long-term changes to the climate, having repercussions for us all. Many experts believe that humanity has already crossed the 'planetary boundaries' for climate change, biodiversity and natural resources. In light of this situation, within the next few years, greenhouse gas emissions need to be drastically reduced and adaptation plans need to be implemented.

Flooded plot during the rainy season in Cambodia

3. Source: IPCC (2018) *Special Report on Global Warming of 1.5 °C*

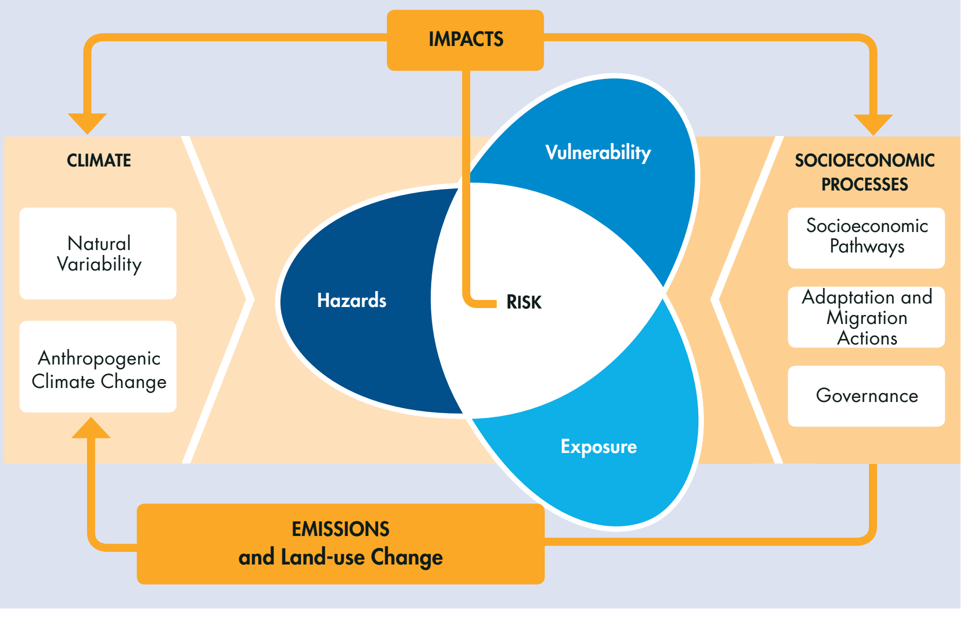
2. Understanding the Impacts on WASH Services

Understanding the concepts of risk and vulnerability

Risk of climate-related impacts results from the interaction of climate-related hazards (including long-term trends and extreme weather events) with the vulnerability and exposure of human and natural systems. The same type of climate-related hazard can have multiple impacts.

In order to adapt to these impacts, it is important to understand **the level of risk** that is considered in relation to each type of **climate-related hazard** and to be aware of the levels of **vulnerability** and **exposure** of the system under consideration.

Figure 1: Links between the concepts of risk, hazards, vulnerability and exposure. Changes in both the climate system (left) and socioeconomic processes including adaptation and mitigation (right) are drivers of hazards, exposure, and vulnerability.[4]



4. Source: IPCC (2014) Climate Change 2014. *Impacts, Adaptation and Vulnerability.* Summary for Policymakers.

It is possible to reduce the risks related to the impacts of climate change by taking action on a number of fronts:

- **Reduce the exposure and vulnerability of systems** by anticipating potential impacts and preparing the appropriate responses. These actions will vary in accordance with the socio-economic and environmental context and with the political decisions taken (**adaptation** measures). → Chapter 4.
- **Combat greenhouse gas emissions** to reduce the intensity and frequency of climate-related hazards (**mitigation** measures) → Chapter 5

It is therefore necessary to have a sound understanding of the different types of climate-related hazards and their potential impacts before embarking on any action.

Key Concepts

A climate-related hazard is the potential occurrence of an event that may cause loss of life or injury, as well as damage and loss to businesses, services and the environment. This can be an extreme weather event or a longer-term trend. *Adapted from: Seine-et-Marne, 2015*

Exposure is the presence of a human or natural element (people, species, ecosystems, environmental functions, economic activities, etc.) in places or settings that could be adversely affected. *Adapted from: IPCC, 2014*

Impact is the effect that a climate-related hazard has on natural and human systems. These effects manifest themselves locally on people's lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure. Impacts are also referred to as *consequences and outcomes*. *Adapted from: IPCC, 2014*

Vulnerability describes the propensity or predisposition to be adversely affected. It encompasses a variety of concepts, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerability can therefore be shaped by a range of factors, including socio-economic inequalities, local urban development and the implementation of adaptation strategies. It is thus linked to an area's political strategies and decisions. *Adapted from: IPCC, 2014*

Key concepts in practice: some examples to better understand

Figure 2: Example to understand the difference between the concepts of vulnerability and exposure

The keys to understanding the concepts of hazard, exposure, vulnerability and risk

Key 1	Key 2	Key 3
Hazard: rising sea levels **Exposure:** coastal areas and islands Potential **impact** on water resources: saltwater intrusion into aquifers **Vulnerability:** high for water supply systems that use groundwater only ↓	**Hazard:** drought **Exposure:** countries in sub-Saharan Africa, and in the Sahel region Potential **impact** on the water service: service interruptions or temporary reductions due to lack of available water resources **Vulnerability:** high for the poorest communities and major cities ↓	**Hazard:** flooding **Exposure:** towns and cities Potential **impact** on water and sanitation services: flooding of infrastructure and facilities, particularly electrical equipment **Vulnerability:** high for urban services, particularly in developing countries ↓
High risk of freshwater shortages and problems with water supply services.	**High risk** of over-using the water resources still available, of water shortages and of a rise in conflicts over access to the resource.	**High risk** of water and sanitation service breakdowns and of an increase in diarrheal diseases.

Identifying the various climate-related hazards

The rise in average global temperatures leads to climate disruption: climate-related **trends**, observable over the long-term, that can generate **extreme weather events** of increasing frequency and intensity.

Climate-related trends:

Rising sea levels,
which pose a threat to coastal areas and islands;

Variability of seasonal rainfall patterns,
resulting in longer dry seasons: average annual rainfall may remain stable but there can be a much longer gap between two rainy seasons;

A rise in average temperatures,
and (maximum) temperature peaks around the world.

Extreme weather events:

Heatwaves,

Periods of drought,
leading to water scarcity;

Greater frequency and intensity of extreme events,
such as torrential rain, storms (including dust and sandstorms), strong winds and cyclones.

All of these climate-related hazards have a significant impact on the large water cycle and on water resources, thus creating a number of risks for water and sanitation services. **Climate-related hazards can generate risks that directly affect the operation of services.**

In sub-Saharan Africa, dry seasons are generally becoming longer, and droughts, heatwaves, and intense rainfall that increases the risk of flooding are all becoming more common.

The impact on water resources

The large and small water cycles are closely linked:

- The level of treatment applied to make the water suitable for drinking and continuity of the water service both depend on the initial quantity and quality of the water resources that are available;
- The quality of natural resources depends on good sanitation, which ensures the safe management of wastewater and excreta.

The main impacts of climate-related hazards on water resources are outlined in the following table:

Climate-related Hazard	Impacts on Water Resources	Vulnerable Areas
Rising sea levels	Seawater intrusion	Islands, coastlines, particularly coastal towns and cities
Variability of seasonal rainfall patterns	Low levels or a lack of surface water and groundwater at the end of the dry season	Regions in the tropics that rely on successive dry and rainy seasons Areas with low rainfall
A rise in average temperatures Heatwaves Droughts	A reduction in the quantity and quality of surface water and groundwater, both seasonally (large-scale fluctuations) and inter-annually (continual fall in aquifer piezometric levels): Reduced river flows, particularly in low-water periods. Higher concentrations of various (chemical and organic) pollutants in the water due to poor dilution. Decreased groundwater recharge. Algae blooms that disrupt water bodies' natural processes (eutrophication/nitrogen cycle). Increased salinity: – River water becomes more saline due to reduced water flows; – Saltwater intrusion into coastal groundwater caused by decreased groundwater recharge; – Changes occur to the geological substratum, releasing elements that lead to the formation of soluble salts.	Areas with low rainfall, arid areas, hot areas Densely populated urban areas

More frequent and intense extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, strong winds, cyclones	Pollution of surface water then groundwater (after infiltration) as pollutants leach into the soil, latrine pits are flooded and higher volumes of wastewater are discharged untreated (as any wastewater treatment plants are overloaded). ↓ QUALITY Poor infiltration of rainfall during intense rainfall events: the ground cannot soak up all the water, which runs off and causes flooding .↓AVAILABILITY and ↓ QUALITY	Agricultural or industrial areas where there are polluting activities Densely populated and soil-sealed urban areas Arid, impermeable soils: clay soils, non-vegetated land, etc.

Chabrouh dam in Lebanon

The impact on water supply services

A sustainable water supply service consists of a number of components, including the extraction (through abstraction or pumping), treatment, storage, and distribution of drinking water to users within a given area. The water distributed should be affordable, of good quality and available in sufficient quantities when needed. The service level is dependent on the local context, needs and technical and financial resources. The service is vulnerable to changes in water resource availability (↓AVAILABILITY) and quality (↓ QUALITY), as highlighted in the previous section, as well as to other climate-related hazards.

The types of risk and the service's vulnerability to these risks should be considered at the water supply system design stage in order to make sure that the facilities selected are properly sized and adapted to the environment, and ensure viability of the system's operation over time.

List of impacts for the water service

In the table below, we have broken down the main impacts of the various climate-related hazards into three types of impact:

1. **Impacts on specific consumption,** which equates to the average volumes of water consumed per user per day, and influences water withdrawals and the lifespan of the water supply service;
2. **Impacts on infrastructure and facilities,** which need to be in good working condition to ensure that the service remains operational and sustainable and the networks remain efficient. A fall in the useful lifespan of facilities can affect economic viability forecasts, which are based on the size of the facilities installed;
3. **Impacts on service quality,** which encompasses the quality of the water distributed and service availability (water supply continuity and the pressure available to the end-user).

These three types of impact are obviously inter-connected but can also be easily linked to monitoring indicators.

Climate-related Hazards	Impact on Specific Consumption	Impact on Infrastructure and Facilities	Impact on Service Quality
Rising sea levels, saltwater intrusion	**Consumption halted** when salt levels in the water distributed reach a certain threshold and the water is no longer suitable for drinking.	**Infrastructure corrosion** (steel, iron, etc.).	**Services halted** due to high salt levels, which cannot be reduced through treatment.
Rise in average temperatures Variability of seasonal rainfall patterns Heatwaves Droughts	**Increase in water needs and in volumes withdrawn** for all uses (domestic, agricultural, industrial, etc.).	**Weakened facilities:** – facilities are over-used during droughts to meet high demand; – dry pumping can damage pumps; – concrete can crack during heatwaves.	**Interrupted or temporarily reduced services** due to lack of available water resources. **Drop in the quality of water distributed** as the raw water, which has high concentrations of pathogens, physico-chemical pollutants, salt, etc., is difficult to treat.
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, winds		**Facilities are weakened, less efficient and damaged:** flooded wells, silting, flooded electrical equipment, erosion of facilities, weakened and burst pipes causing network leakages, etc. **Water reservoirs are weakened** after having been placed under too much pressure and stress.	**Service interruptions** due to damaged facilities. **Water points are inaccessible** (landslides – floods). **Drop in the quality of water distributed** due to greater pollution and higher turbidity of water resources caused by soil leaching and flooded sanitation facilities.

Health, social and economic impacts

Drops in service quality or service interruptions caused by climate-related hazards and falls in the quantity and quality of water resources can have serious health and social impacts. The risks are often greatest for the most vulnerable (women, children, the elderly and disabled, the poor, people living in crisis situations, refugees) as they are the most exposed.

- **Increase in diarrheal diseases** when there is a drop in service quality and people use alternative and poorer quality water resources during service interruptions;
- **Increase in conflicts of use** during periods of water scarcity;
- **Greater migration** or people leaving as they have no water, creating political, social and environmental issues;
- **More difficulty involved in the chore of drawing water** because people have to travel greater distances and pumping takes longer as the water table is lower and less productive.

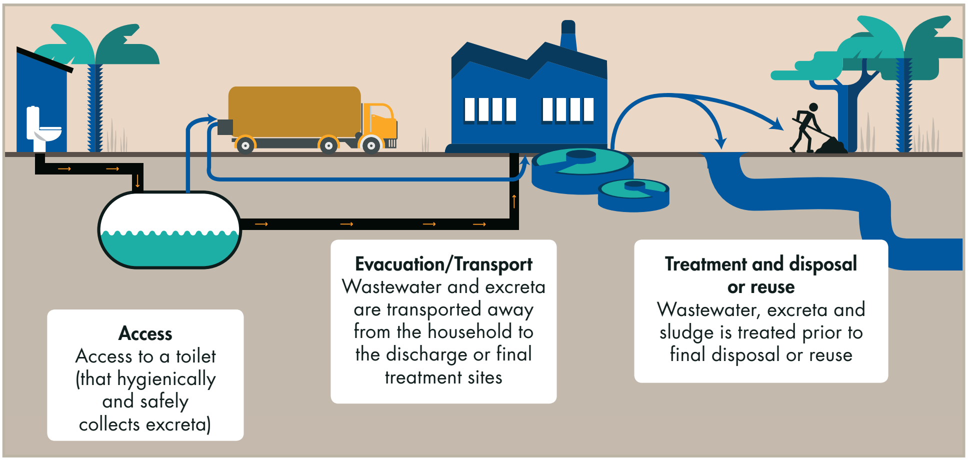
The various direct impacts on the water service and their effects on people's health and well-being have economic repercussions. Additional costs incurred due to the impacts of climate change (replacing damaged equipment, maintenance, etc.) can jeopardise the viability of the water service. Furthermore, the lack or reduction of water services also impact people's livelihoods.

Women and girls have to travel longer distances to collect water in water-scarce areas. This photo shows Ugandan women carrying water.

The impact on sanitation services

The main focus of sanitation is to minimise the health and environmental risks of failing to hygienically dispose of pathogen-containing wastewater and excreta. Implementation of a sustainable sanitation service is a human right that entitles every person to have access to toilet facilities that ensure privacy and dignity.

A complete sanitation service consists of three segments.



The entire sanitation chain can be exposed to a range of climate-related hazards. It is also important to protect water resources as climate change weakens natural ecosystems.

There can thus be:

- **Impacts on service operations,** such as damage to infrastructure or disruptions to treatment processes;
- **Impacts on the environment,** particularly on natural ecosystems and water resources;
- **Social and health impacts.**

Population growth, higher living standards and economic development tend to increase specific drinking water consumption and, thus, the volumes of wastewater produced. These variables can exacerbate the vulnerability of sanitation services.

As with water supply services, a sanitation service's operations, monitoring, management and funding all need to be sustainable. These aspects will be indirectly affected by the impacts of climate change.

Climate-related Hazards	Impact on Service Operations	Impact on the Environment	Social and Health Impacts
Rise in average temperatures Variability of seasonal rainfall patterns Heatwaves Droughts	**Biological treatment processes fail to function.** **Condition of infrastructure and facilities deteriorate:** for instance, concrete structures deteriorate due to the increased production of hydrogen sulphide[6] (H_2S).	**The wastewater discharged is not properly treated and there is a lower dilution of pollutants** resulting in: – **A drop in water resource quality.** – **Disruptions to ecosystems and biodiversity**, especially aquatic ecosystems.	**Olfactory pollution** due to increased nitrous oxide emissions (N_2O). Hydrogen sulphide (H_2S) production is exacerbated by the heat increasing the **risk to staff of poisoning through H_2S inhalation,** especially sewer workers.
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, winds	**Collapse of latrines** not built to recognised standards (this can have a significant impact on access rates). **Pit emptying services are disrupted** (some areas become inaccessible, pits need emptying more frequently, etc.). **Flooding leads to breakdowns** on sewer systems' lift pumps and electrical systems. **Treatment processes fail to function correctly** due to hydraulic overload.	**Increase in untreated wastewater discharged into the environment** as: – Toilet pits are flooded and a mixture of wastewater and stormwater overflows onto public roads; – Stormwater runs into the sewers causing these to overflow, lift pumps become flooded and wastewater treatment plants are by-passed.	**People no longer have working sanitation facilities available,** as these have been destroyed or can no longer be used. **Increase in waterborne diseases** as there is a higher risk of people coming into contact with polluted water.

6. Hydrogen sulphide, H_2S, is a toxic gas that results from the breakdown of organic matter and, as it is heavier than air, it collects in unventilated and closed-off areas, such as sewers and pipes. Heat increases its production.

The impact on stormwater management

Stormwater management can be defined as *all the measures undertaken to improve the way in which the flow and volumes of water generated by rainfall and surface run-off in residential areas are controlled and managed.*[7]

The risk is predominantly health-related as lack of stormwater management increases the likelihood of coming into contact with polluted water (from contaminants in the soil, from flooded cesspits or from stormwater infiltrating and saturating sewers), especially in unplanned urban settlements where vulnerability is higher. A lack of proper stormwater management can also have environmental, economic and safety implications. Growing urbanisation is exacerbating exposure to risk, particularly in developing countries, as a result of soil sealing.

There is generally very little or no urban stormwater management in developing countries. In towns and cities that do have stormwater drainage schemes, these only cover the wealthiest or most central areas and are often in a poor state of repair from lack of proper maintenance.

Furthermore, the stormwater management facilities that are currently in place are unable to withstand extreme rainfall events.

The link between sanitation, stormwater and climate change

The sanitation service and stormwater management are closely linked. In the dry season, wastewater entering into stormwater drainage schemes can produce bad smells and create hygiene issues (contaminating water, acting as vectors for disease, etc.). In the rainy season, stormwater combines with wastewater and excreta, contaminating flooded areas and the environment.

7. pS-Eau (2013) *La gestion des eaux pluviales (GEP) en milieu urbain dans les pays en développement,* Working document (in French)

The increased frequency and intensity of extreme weather events due to climate change makes towns and cities more vulnerable to the impacts of having no sanitation or stormwater management system.

Rainfall in countries in the Sahel and tropical and equatorial regions can be extremely intense, which makes installing effective urban stormwater drainage systems more difficult and costly in low-resource settings.

List of impacts on stormwater management

Climate-related Hazards	Impact on Stormwater Management and, indirectly, on Water and Sanitation Services	Impact on Housing, Public, Industrial and Commercial Facilities	Social and Health Impacts
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding	**Facilities are flooded** and stormwater management infrastructure is not designed to cope with extreme weather events. For water and sanitation services, this means that: **equipment is flooded and sewers overflow, etc.**	**Housing is damaged** (or destroyed). **Communication routes are cut off** and **there are interruptions to the other networked services** (electricity, telephone, etc.). **Economic activities are disrupted / forced to close.**	**Population displacement** as dwellings are no longer habitable. **Accidents, injuries and drowning** due to flooding, landslides and traffic accidents. **Increase in waterborne diseases** that are spread by: – People using contaminated water for domestic use; – An increase in carriers of disease, such as mosquitoes, rats, etc. **Public and private property is frequently damaged.**

3. Taking Action: Key Considerations and Responses

Understanding the concepts of adaptation and mitigation

There are **two complementary approaches that can be implemented** to minimise climate change-related risks: adaptation, which seeks to reduce the exposure and vulnerability of systems; and mitigation, which focuses on tackling global warming by reducing greenhouse gas emissions.

Climate change adaptation

Climate change **adaptation** is defined as the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. *Source: IPCC, 2014*

• Adaptation to climate change is now inevitable

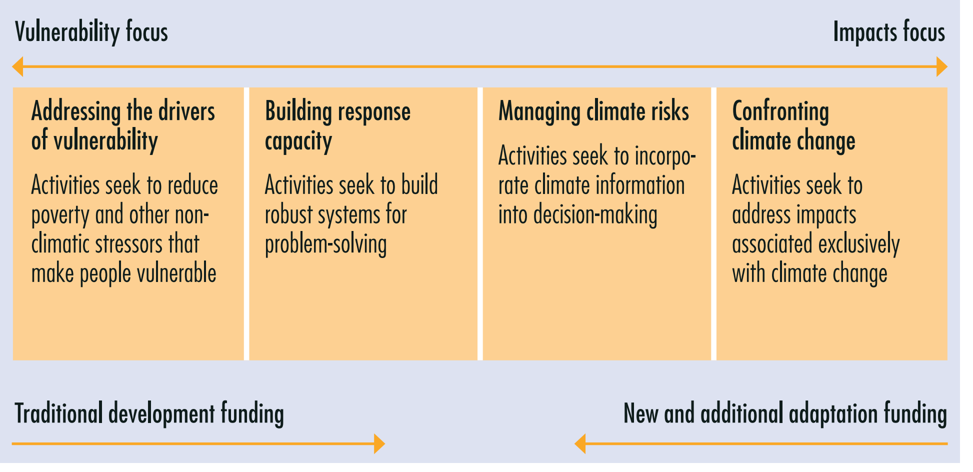
Whether planned or unplanned, adapting to the impacts of climate change is inevitable as the effects of the rise in average global temperatures can already be seen and will intensify, even under the most optimistic global warming scenarios.

The adaptation strategy should thus anticipate the impacts of climate change and take these into account in order to identify the best location for building facilities and infrastructure and develop sustainable services. Thus, adaptation measures should be adopted at the local level in order to effectively meet an area's needs. The adaptation approach involves reducing the exposure and vulnerability to climate-related hazards of human and natural systems. This approach should promote flexible decision-making and good governance in order to avoid **mal-adaptation.**

• Reducing vulnerability

The distinction between climate change adaptation activities and development activities is a subject of much debate. In most cases, adaptation involves efforts to reduce vulnerability in a 'normal' development situation. This could be viewed as an adaptation continuum: on the one side are activities that seek to reduce vulnerability to specific climate change impacts and, on the other, there are activities that seek to address development-related vulnerability factors (poverty and other non-climate change related factors).

Figure 3: The adaptation continuum[8]



• Reducing exposure

Reducing a system's exposure to climate-related hazards is a vital component of the climate change adaptation approach. This type of adaptation measure can include building infrastructure in carefully selected locations, as well as defining plans for moving and re-housing people from flood zones or high-risk areas.

Avoiding mal-adaptation to climate change

The concept of mal-adaptation is used to define a change made to human or natural systems to address climate change that (unintentionally) increases rather than reduces vulnerability. The following are all examples of mal-adaptation:

- **Inefficient use of resources when there are other, more suitable, options available** (for instance, introducing desalination technology when protecting and effectively treating groundwater resources would suffice);
- **The uncontrolled transfer of vulnerability** (for instance, pumping water from deep aquifers for a settlement without first discussing this at river basin level and potentially reducing the water available for other river basin communities);
- **Design errors:** poor or sub-optimal adaptation (for instance, building a retaining wall too low to offer sufficient protection).

Source: French Ministry for Ecological and Inclusive Transition

8. Source: Roger Calow et al (2011) *Climate Change, Water Resources and WASH.* ODI BGS.

Climate change mitigation

Mitigation refers to activities that seek to minimise the scale of climate change by reducing direct and indirect greenhouse gas emissions. *Adapted from: ADEME, 2012*

This notably includes **reducing energy consumption and significantly increasing the use of renewable energy sources**. Pursuing this objective also makes it possible to reduce local costs and improve service sustainability.

The benefits of mitigation can be felt on a global scale, which means collective efforts are required to effectively tackle the rise in global temperatures.

Water storage and solar pumping in Madagascar

Stakeholders and scales of intervention

There are a number of intervention frameworks in place that cover complementary strategic levels (see the table below). When taking action to tackle climate change, all of these different reference frameworks should be taken into account. It is also important to involve all stakeholders in implementing the activities defined.

The various strategic frameworks and stakeholders

Level	Reference Frameworks	Stakeholders
International	– The resolution on the human right to water and sanitation adopted by the UN General Assembly on 18 December 2013	– UN
	– The Sustainable Development Goals adopted by the UN General Assembly on 27 September 2015	– UN
	– The Paris Climate Agreement of 12 December 2015	– UN
Sub-Regional	– Transboundary river management plans	– River basin organisations – Regional economic commissions – Governments – Governments and water and sanitation ministries
	– Regional water resource management action plans	
	– Regional declarations on water and sanitation (e.g. the Ngor and eThekwini declarations on water and sanitation in Africa)	
National	– Development and poverty reduction strategies	– Ministries of water, sanitation, the environment and other related sectors (health, urban planning, finance, decentralisation, infrastructure, etc.)
	– Water and sanitation sector policies and national action plans	
	– Water, sanitation and environment acts	
	– National climate change adaptation plans	
Local	– Local development plan – Water and sanitation master plan / sector plans – Water management plan – Climate plan – Risk prevention plan	– Local authorities – Devolved government agencies: water, sanitation, the environment, health, etc. – Service managers – River basin agencies – Consultancy firms, companies – NGOs – Users

The broad scope of climate change's impact on human society, ecosystems and biodiversity requires global and cross-sector responses. Thus, it is recommended that **water and sanitation service adaptation or mitigation plans factor in linkages with the large water cycle and other sectors** (energy, agriculture, etc.). This approach is in line with the Sustainable Development Goals, which are also inter-linked.

The role of local communities, a challenge when designing interventions

One of the major adaptation challenges lies in ensuring **communities play a role, and local people are involved**, in developing and implementing adaptation plans and strategies. The key is to find appropriate responses to meet local communities' needs and, at the same time, to address the various levels of climate risk. To this end, **particular attention should be paid to the most vulnerable population groups, as well as to indigenous peoples.**

Consultation has a range of advantages. It provides a collective approach for assessing and taking ownership of the issues identified, and ensures stakeholders remain committed over the long-term and involved in implementing activities. Responses should thus combine structural (infrastructure, techniques) and non-structural (or 'soft') approaches, such as awareness-raising.

It will be important to **recognise and take local knowledge and practices into account.** It has been noted that local people's knowledge of climate change is essentially based on their observation of nature and climate phenomena. In many areas around the world, people have modified their practices to adapt to climate change.

Consultation meeting in Bangladesh

Operational considerations

Making decisions in a context of uncertainty

Implementing adaptation measures is complex because we have only partial knowledge of the impacts of global warming and thus uncertainties abound. These uncertainties can be a barrier to committing to an adaptation approach and to defining strategies.

They can relate to:

- **The global climate change scenario:** the IPCC Special Report on Global Warming of 1.5°C reveals that not only will the impacts of global warming above +2°C be more serious than if it is restricted to +1.5°C, but also that the risks increase at a faster rate than the temperature.
- **The local effects of global scenarios:** the impacts of global warming will be different for each region and vary in accordance with their level of development, their vulnerability and the adaptation and mitigation measures put in place. It is particularly difficult to predict the scale of extreme rainfall events, which in turn makes it difficult to design effective stormwater management systems.
- **The response to climate change of natural and human systems:** there is great uncertainty surrounding the changes that could potentially occur to the large water cycle, land-based and aquatic ecosystems (seas and oceans, forests, rivers and lakes, etc.), biodiversity and human societies.

Given such uncertainties, embarking on an adaptation approach could appear futile. However, it is important to remember that climate change will always entail adaptation, whether planned or otherwise. It is also useful to bear in mind that, despite these uncertainties, many adaptation measures can have benefits for development, tackling inequality and poverty reduction.

A range of approaches and measures should be used to counteract some of the uncertainties over future scenarios:

- **Develop data sharing, production and monitoring systems** by adapting indicators to include climate change concerns;
- **Rank and prioritise responses** based on the level of the assessed risk and available resources;
- **Opt for flexible adaptation measures** that can be adjusted as more information becomes available;

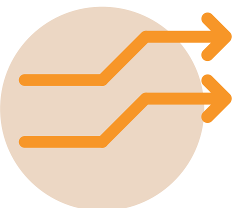
- **Select 'no regret' options**, namely responses that have immediate benefits and remain relevant regardless of the climate scenario (including a scenario with no climate change). One example of this would be water-saving measures;
- **Adopt a long-term vision** that focuses on service sustainability, synergies between sectors and environmental protection.

No-regret option

No-regret options are measures or activities that will prove worthwhile even if no (further) climate change occurs.

For example, early warning systems for floods, drought management plans and water safety plans will be beneficial even if the frequency of the extreme events does not increase as expected. *Source: Guidance on Water and Adaptation to Climate Change, Economic Commission for Europe, 2009*

Supporting transitions



Adaptation or mitigation approaches need to be supported, and assistance should be provided to facilitate their implementation. Ensuring that an enabling environment is in place for these approaches involves:

- Adapting the public action framework

Implementing adaptation or mitigation measures will sometimes first entail adapting legal and regulatory instruments to address these new challenges. For sanitation, this can mean ensuring there is regulatory and public authority support for using wastewater treatment by-products and for treated wastewater reuse (use of treated sludge as an agricultural fertiliser, use of biogas, etc.).

When provided by the government to its local authorities or devolved agencies, financial incentives for investing in high-performance equipment can be useful tools for promoting engagement.

• Climate finance

The issue of climate finance is also the subject of much debate, particularly among international bodies.

Although economic and societal transition is an imperative, it requires huge amounts of funding. Mitigation entails a fundamental change to energy systems. Adaptation also has an economic cost that the majority of developing countries are unable to afford, particularly as they already have other, socio-economic issues to address. The World Bank estimates that the cost of adaptation for the water sector amounts to between US$13.3 and 16.9 billion per year between 2010 and 2050, and this does not include the adaptation cost of water for agricultural use.[9] The concepts of solidarity between communities and the responsibilities of developed countries towards developing nations are thus central to finance-related negotiations.

It has become necessary to develop funding mechanisms to tackle climate change and its impacts. International funds have been set up, such as the Green Climate Fund, created under the UNFCCC, and the Adaptation Fund, established under the Kyoto Protocol; however, this funding remains difficult to obtain and is earmarked for large-scale projects. There are also other finance mechanisms available, including multi-lateral or national funds that have incorporated climate change into their activities.

Nevertheless, some countries struggle to access these funding streams, particularly when seeking to finance adaptation projects. Access to many of the funding schemes is restricted by complex procedures and, for others, countries have to go through international financial institutions or regional banks as the funds are not released to them directly. Some countries lack the proper national frameworks, which makes it more difficult for them to secure funding. For instance, shortcomings can include: an inadequate legal framework; no national climate change strategy; or a lack of skills and weak technical and financial management.

• Using collaborative approaches

Consultation ensures that the most appropriate technical responses and organisational and legislative measures are collectively defined for developing the sector. These shared and jointly upheld 'principles and values' are the cornerstones of robust and effective master plans. The consultation process is just as important as the strategy document produced as it plays an educational and collective learning role and promotes information-sharing and discussion, facilitating ownership by all stakeholders and, in particular, by the public.

Participation and consultation are especially important for tackling climate change. They ensure everybody takes ownership of climate change issues and help create a shared vision for implementing the adaptation and mitigation measures identified.

9. *Source: Coalition Eau (2014) Eau et changement climatique. Note de recherche.*

This approach also promotes the sharing of experiences and ensures the problems encountered are escalated, thereby enabling ongoing improvements to be made to the measures defined as they are being implemented.

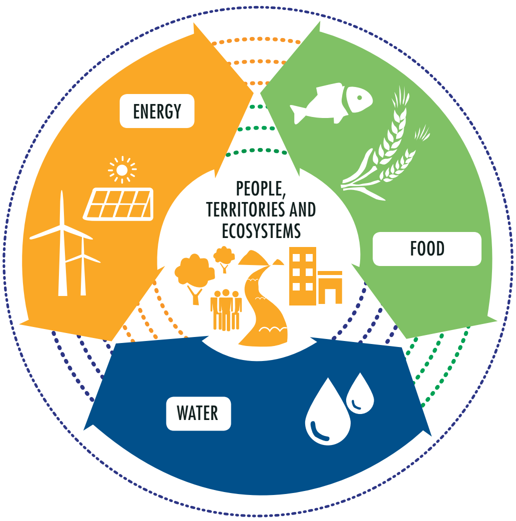
Promoting synergies

Effective climate change adaptation requires a cross-sector approach, notably in order to prevent conflict between sectors and to consider trade-offs and synergies between potential responses.

Water and sanitation services should thus be considered in conjunction with:

- Regional and river basin **water resources management;**
- **Agriculture**, a sector that consumes water but also offers the potential for using sanitation by-products;
- The **energy sector**, which is required for operating water and sanitation services and also offers the potential for using sanitation by-products;
- Other **basic services (stormwater management**, solid waste management, etc.), particularly in towns and cities.

Conversely, an uncoordinated adaptation response can be counterproductive and increase the vulnerability of other sectors. For instance, prioritising domestic uses in order to manage resources often means liaising closely with the agricultural sector, which could be adversely affected during droughts.



4. Adaptation Measures

The aim of adaptation is to anticipate the impacts of climate change and reduce the associated risks by taking action to minimise the vulnerability and exposure of systems.

Key steps for taking action[10]

A. Asses the climate change-related risks

The first step involves assessing **risks to the water or sanitation service**. It is therefore necessary to identify:

- Climate-related hazards and the potential impact these may have on the service;
- The extent to which the different segments of the service are exposed;
- The service's vulnerability to each hazard.

This risk assessment step should form an integral part of all assessments conducted when developing a water or sanitation service. The assessment should be carried out using an integrated management approach at the appropriate level, be it the national, river basin or local level, for instance. The review should incorporate an analysis of existing strategies, plans and studies to identify the efforts already being made to promote adaptation.

It is necessary to involve all relevant stakeholders at this initial stage in order to establish a common core of climate risk knowledge, which will be useful going forward. Coordination between sectors (water supply, sanitation, water resources, energy, agriculture, etc.) may be required to enhance overall knowledge of climate change impacts. **The assessment can be used to prioritise the actions to be taken.**

• Risk assessment methods

Although not all are specific to water and sanitation services, there are a large number of risk assessment methods available and these are provided as references in Appendix 74. Many of these risk assessment approaches use a scoring system, with points allocated to different parameters (hazards, exposure, vulnerability, etc.). The score obtained by adding up all these points corresponds to the level of risk: low, medium or high. This helps to rank and prioritise adaptation needs based on the scale of the threat

10. These steps are inspired from the 'Strategic Framework for WASH Climate Resilient Development' developed by the Global Water Partnership.

B. Develop and implement solutions

Include adaptation options in policies and strategies

Incorporating climate issues into national and local policies and strategies is a prerequisite for taking action.

This step facilitates implementation of more operational measures by proposing a course of action for embarking on transitions. The task of developing an adaptation strategy and policy should provide an opportunity to **define adaptation objectives for water or sanitation services** in conjunction with all stakeholders and ensure that these objectives are aligned to other strategies (Sustainable Development Goals, national contributions for the Paris Climate Agreement, etc.)

When committing to implementing adaptation and mitigation approaches, it will be necessary not only to **adapt current regulations** but also to provide sector stakeholders with relevant information and skills training.

Develop and implement an action plan

Once the adaptation objectives have been defined, the **next step consists of developing a local, realistic and timetabled action plan.**

This second step should help determine the most appropriate options and activities for the risks identified during the assessment. The planning process involves identifying priority actions for which the climate risk is high, and building on the adaptation objectives set out in policies and strategies. It should also take into account the availability of human, financial and technical resources within the area under consideration.

When implementing activities, monitoring milestones and a stakeholder support procedure should both be put in place.

- Examples of types of action

- The action plan can include new procedures that take greater account of climate risk, such as an in-depth water demand assessment, a technical study on the most frequent and intense hazards, or a procedure to define and select suitable service management methods, etc.;
- Existing approaches, such as integrated water resources management or water safety management plans, can be revised to include climate issues;
- A **risk culture** can be developed in order to anticipate emergencies, by improving early warning systems, for example.

Risk culture

Developing a risk culture means that all stakeholders (elected officials, technical staff, the general public, etc.) are aware of natural phenomena and understand vulnerability. Informing people, and doing so from an early age, is the key driver for advancing risk culture. This culture of risk should help people acquire rules of conduct and reflexes, as well as collectively discuss practices, positions, issues, and so on. Developing risk culture means improving the effectiveness of prevention and protection. By making people aware of the appropriate behaviours to use when a major event occurs, risk culture helps improve risk management.

Source : French Ministry for Ecological and Inclusive Transition

C. Monitor and learn from experience

As with all public policies, it is necessary to be able to monitor and assess implementation of the adaptation policy. This helps to ensure the expected benefits are achieved and to improve future action. This step will involve **defining monitoring indicators and developing monitoring and evaluation mechanisms**. Various types of indicator can be used to cover the scope of the policy.

• Adapt the technical and financial monitoring of services [11]

Specific climate vulnerability indicators can be added to existing technical and financial monitoring mechanisms. These indicators could include: the level of the water table, the quality of the wastewater discharged into the environment, and the frequency of service interruptions linked to climate-related hazards.

11. For more information, see 'Monitoring and Evaluation (M&E) Method for Climate Change Adaptation Policies. Methodological Guide' (2013) ADEME.

Adaptation for water services

Objectives

All actions to develop the water service should be linked to the SDG implementation framework. The aim of target 6.1 of SDG 6 is to "achieve universal and equitable access to safe and affordable drinking water for all" by 2030.

Therefore, climate change adaptation measures should seek to ensure that:

- Everyone has access to the service, particularly the most vulnerable population groups;
- The service is available as and when required;
- The water distributed is of good quality, and free from faecal and priority chemical contamination.

The tables below list a range of adaptation options that could be implemented as a response to the various impacts identified in Chapter 2 p16.

Reducing the risks of impacts on specific consumption

Climate-related Hazards	Impact on Specific Consumption	Adaptation Measures
Rise in average temperatures Variability of seasonal rainfall patterns Heatwaves Droughts	**Increase in water needs and in volumes withdrawn** for all uses (domestic, agricultural, industrial, etc.)	**Conduct an 'enhanced' demand assessment** that factors in the availability of resources. The aim is to anticipate water demand during periods of water scarcity or water stress in order to adapt service management to all possible scenarios. **Demand management:** the water savings made by properly managing demand will ensure more resources remain available. This demand management can involve: adapting the pricing schedule in line with consumption patterns; raising customer awareness (information and awareness-raising campaigns during water shortages) and monitoring large consumers.

Reducing the risks of impacts on infrastructure and facilities

Climate-related Hazards	Impact on Infrastructure and Facilities	Adaptation Measures
Rising sea levels, saltwater intrusion	**Infrastructure corrosion** (steel, iron, etc.).	**Use corrosion-resistant materials or ensure proper maintenance (**anti-corrosion treatment, monitoring and replacing parts before they break).
Rise in average temperatures Variability of seasonal rainfall patterns Heatwaves Droughts	**Weakened facilities:** – facilities are over-used during droughts to meet high demand; – dry pumping can damage pumps; – concrete can crack during heatwaves.	**Introduce additional specifications** for feasibility studies, service design, facility monitoring and inspections that incorporate climate risks. **Strengthen the robustness of infrastructure facilities:** procure high quality materials, ensure proper maintenance, etc. **Expand the number of water withdrawal and network interconnection points** to ensure service continuity in the event of a breakdown.
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, winds	**Facilities are weakened, less efficient and damaged:** flooded wells, silting, flooded electrical equipment, erosion of facilities, weakened and burst pipes causing network leakages, etc. **Water reservoirs are weakened** after having been placed under too much pressure and stress.	**Introduce additional specifications** for feasibility studies, service design, facility monitoring and inspections that incorporate climate risks. **Adapt the dimensions** of storage facilities and weirs or overflows to include the appropriate margins. **Construct retention basins** to protect facilities and promote re-infiltration. Nature-based solutions can be highly applicable in this context.

Reducing the risk of impacts on service quality

Climate-related Hazards	Impact on Service Quality	Adaptation Measures
Rising sea levels, saltwater intrusion	**Services halted** due to high salt levels, which cannot be reduced through treatment	**Diversify drinking water sources:** treated surface water, water transfers, rainwater, and desalination. This measure provides the opportunity to review the water quality required, which could vary for different types of use.
Rise in average temperatures Variability of seasonal rainfall patterns Heatwaves Droughts	**Interrupted or temporarily reduced** services due to lack of available water resources. **Drop in the quality of water distributed** as the raw water, which has high concentrations of pathogens, physico-chemical pollutants, salt, etc., is difficult to treat.	**Improve knowledge of the resource:** install tools to monitor changes to the water table, and monitor water quality to anticipate water treatment adjustments. **Adapt the service to ensure continuity:** – Select water supply technologies: water desalination, raw water transfers to cover periods when local resources are not available in sufficient quantities or quality; – Increase the storage capacity of facilities used to produce drinking water between rainy seasons; – Expand the number of water withdrawal points and ensure these are rationally distributed; – Link up water supply systems to scale-up management and sharing of the resource.

		Resource protection and management *It is worth considering all of these measures together as part of an integrated water resources management approach. Measures specific to the water service include:* – Respect the balance between groundwater abstraction and recharge; – Protect the resource from pollution (restrict chemical inputs, sewage, etc.) – Prioritise allocating the resource to domestic uses in an equitable manner; – Reuse wastewater to relieve the pressure on other water resources; – Promote infiltration and aquifer recharge; – Improve the efficiency of the distribution network, notably by reducing water losses.
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, winds	**Service interruptions** due to damaged facilities. **Water points are inaccessible** (landslides – floods). **Drop in the quality of water distributed** due to greater pollution and higher turbidity of water resources caused by soil leaching and flooded sanitation facilities.	**Prepare for extreme weather events:** create a risk culture, develop emergency plans. **Develop warning systems** to anticipate extreme weather events and rapidly adapt service management accordingly. **Monitor water quality** and introduce the appropriate treatment. **Systematically produce risk assessment plans** that include climate risks, identify vulnerable users (hospitals, etc.) and contain information on the steps to be taken by service managers, operators and users in the event of an emergency. *The effectiveness of all of these measures can be enhanced by designing them in conjunction with the adaptation measures for wastewater and stormwater management.*

Reducing the risks of health and social impacts

A key aspect of adaptation involves taking the health and social impacts of climate change into account. In a context of 'normal' development, it can be difficult to differentiate between these adaptation measures and efforts to reduce vulnerability → p31-32.

Adaptation measures for the water service need to consider **access to the service:**

- Particular attention should be paid to ensuring universal and affordable access to the service;
- When defining **water service management arrangements**, consideration should be given to the sharing of resources, particularly during periods of drought and water scarcity. Multiple-use resource management could be used in this situation to ensure basic needs are met and to maintain livelihoods (growing crops, watering cattle, etc.). This will involve ensuring that specific needs are taken into account, such as the water needs of pastoralist nomadic groups;
- **Access to drinking water in humanitarian situations** has become a growing concern thanks to the increase in migration and natural disasters. When drawing up plans to provide access to sanitation and water supply in these contexts, consideration should also be given to ensuring the sustainable distribution of water to the local community, who can also suffer from a lack of access.

Lastly, a key criterion for adaptation measures is **gender mainstreaming**. Women and children are traditionally responsible for collecting water and are particularly vulnerable to the impacts of climate change on the water service. Efforts should therefore be made to ensure they are involved throughout the adaptation process.

Adaptation for sanitation services

Objectives

As for the water service, actions to develop the sanitation service should be linked to the SDG implementation framework.
Target 6.2 of SDG 6 seeks to "achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations" by 2030. This target is linked to target 6.3, which aims to "improve water quality by reducing pollution [...] halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally".

Climate change adaptation measures for the sanitation service should seek to ensure:

- **Everyone has access to toilets** that ensure dignity (safety and privacy);
- **Excreta is 'safely managed'**, meaning that human waste is kept hygienically separate from human contact throughout the sanitation chain, through to its reuse or treatment.

The different adaptation options that can be implemented to respond to the various impacts on the sanitation service → Chapter 2 p16 are outlined below.

Reducing the risks of impacts on service operations

Climate-related Hazards	Impact on Service Operations	Adaptation Measures
Rise in average temperatures Variability of seasonal rainfall patterns Heatwaves Droughts	**Biological treatment processes fail to function** (certain bacteria die). **Condition of infrastructure and facilities deteriorate:** for instance, concrete structures deteriorate due to the increased production of hydrogen sulphide[12] (H_2S).	**Regularly monitor these treatment processes and adapt them to any changes in climate conditions.** **Monitor and eliminate hydrogen sulphide.**
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, winds	**Collapse of latrines** not built to recognised standards (this can have a significant impact on access rates). **Pit emptying services are disrupted** (some areas become inaccessible, pits need emptying more frequently, etc.). **Flooding leads to breakdowns** on sewer systems' lift pumps and electrical systems. **Treatment processes fail to function correctly** due to hydraulic overload.	*The effectiveness of all of these measures can be enhanced by designing the adaptation measures for wastewater and stormwater management together.* **Build latrine foundations using erosion-resistant materials.** **Install** (I) **a stand-alone power production system** (generator and fuel stored in a secure location that can be used in the event of flooding) and (II) **electro-mechanical equipment** (motors, control panels) **above the potential flood level.**

12. Hydrogen sulphide, H_2S, is a toxic gas that results from the breakdown of organic matter and, as it is heavier than air, it collects in unventilated and closed-off areas, such as sewers and pipes. Heat intensifies its production.

Reducing the risks of impacts on service operations

Climate-related Hazards	Impact on the Environment	Adaptation Measures
Rise in average temperatures Variability of seasonal rainfall patterns Heatwaves Droughts	**The wastewater discharged is not properly treated and there is a lower dilution of pollutants** resulting in: – **A drop in water resource quality.** – **Disruptions to ecosystems and biodiversity,** especially aquatic ecosystems.	**Improve wastewater treatment capacity prior to discharging wastewater into the environment.**
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, winds	**Increase in untreated wastewater discharged into the environment as:** – stormwater runs into the sewers causing these to overflow, lift pumps become flooded and wastewater treatment plants are by-passed; – toilet pits are flooded and a mixture of wastewater and stormwater overflows onto public roads.	*The effectiveness of all of these measures can be enhanced by designing the adaptation measures for wastewater and stormwater management together.* **Install separate sewer systems** for wastewater and stormwater. **Minimise stormwater intrusion into the sewers.** **Create buffer ponds.** **Increase treatment capacity.** **Dig pits on higher ground** (or as a minimum, place the pit outlet above the potential flood level) **or install pits with airtight seals.**

Reducing the risk of impacts on stormwater management

Implementing adaptation measures for water and sanitation services provides an opportunity to **develop synergies with other basic services**, particularly in urban areas.

There is a particularly strong link between sanitation and stormwater management during extreme weather events (torrential rain, flooding, etc.), when stormwater management facilities become flooded, rainwater can enter the sewers.

Many of the stormwater adaptation measures also help to enhance the adaptation capacities of the sanitation service.

Climate-related Hazards	Impact on Stormwater Management	Adaptation Measures
Increase in the frequency and intensity of extreme weather events: Sudden and intense rain events leading to an increased risk of flooding Storms, winds	**Facilities are flooded** and stormwater management infrastructure is not designed to cope with extreme weather events. For water and sanitation services, this means that: **equipment is flooded and sewers overflow, etc.**	**Actions to reduce the extent of flooding:** – Manage surface run-off upstream of the town or city; – Ensure stormwater infiltration and reuse at individual plot level; – Minimise soil sealing; – Lay porous road surfaces; – Ensure drainage systems are appropriately designed, built and maintained. **Actions to halt the urban development of areas at permanent risk** **Actions to minimise the risk to people and property during rain events:** – Introduce weather forecasting tools able to determine the magnitude of rain events; – Install public warning and evacuation systems in high-risk areas; – Develop measures to temporarily protect safety equipment. *All solutions implemented should be consistent with those introduced in the surrounding upstream and downstream areas. Nature-based solutions are often well suited to these integrated approaches and can provide an alternative to technological investment or infrastructure construction and maintenance that is economically viable and sustainable and often more cost-effective over the long-term.*

Reducing the risks of health and social impacts

The health and social impacts of lack of sanitation, even outside the context of climate change, have been widely documented. The risks for sanitation services increase sharply during extreme weather events, such as during periods of torrential rain and subsequent flooding.

Adaptation measures for the sanitation service should seek to **reduce the risk of water-borne diseases** by ensuring that:

- Everyone has access to toilets, including in emergency situations. For instance, this could **include installing temporary** toilets until sanitation facilities are reconstructed following a disaster;
- Water that is safe to drink and domestic water treatment systems are provided during periods of emergency;
- Public awareness-raising campaigns are conducted on hygiene, particularly hand-washing.

Reducing the exposure of communities should also not be overlooked. Despite being complex to implement, action can sometimes be required to move people out of exposed areas (coastal areas flooded by rising water levels, informal outlying settlements built on marshland or in flood-prone areas, etc.). The effectiveness of protection and prevention measures can be improved by developing a **risk culture.**

Specific attention should be paid to **gender mainstreaming** when developing sanitation service adaptation measures. Migration and population displacement can mean women feel less safe when using toilets and find it more difficult to manage menstrual hygiene.

Finally, consideration should be given to reducing the **olfactory pollution** created by sanitation facilities, and that can result from an increase in temperatures, as this can affect people's acceptance of the service. The production of hydrogen sulphide (H2S) also poses a safety risk, particularly in confined spaces; this risk can be moderated by regularly monitoring and eliminating this gas.

5. Mitigation Measures

In addition to adaptation, **efforts to tackle climate change also involve seeking out low greenhouse gas emitting technical solutions**. These technical options should be assessed and selected to ensure they provide appropriate, operational and sustainable responses.

Although water and sanitation services produce relatively low emissions of greenhouse gases, implementing a mitigation approach can also help control operating costs. Energy costs, such as for pumps or transport (vacuum trucks, for example), account for a significant proportion of operating expenditure. The mitigation approach is also useful for assessing a service's vulnerability to its energy consumption (reliance on energy supply and price fluctuations).

The main sources of greenhouse gas emissions for water and sanitation services are:

- **Energy** (electricity, fuel, natural gas), the production of which emits greenhouse gases;
- **Wastewater and excreta**, which are natural sources of greenhouse gas emissions, plus their **treatment processes**.

Key steps for taking action

For water and sanitation services, the aim of mitigation is to **reduce both direct and indirect greenhouse gas emissions.**

A. The first step involves **studying greenhouse gas emissions and identifying the activities that produce the most greenhouse gases**. The scope of the study thus needs to be defined beforehand. For instance, does this cover water production only or does it also include water distribution?

B. This greenhouse gas emission information can then be used to **define a mitigation strategy**. Mitigation measures can take various forms, such as: revising production methods; changing behaviours; reviewing strategic aspects (communication, marketing, awareness-raising, innovation, etc.); promoting innovative practices, and so on

C. The final step involves **developing an action plan** that sets out how to implement the mitigation approach. This can include progressive measures that set relevance criteria to be met by activities, such as the activity's contribution to overall emissions, its strategic importance, vulnerability (fluctuations in fossil energy prices, stringent regulations, etc.), and the options available to the organisation for reducing this activity's emissions.

In order to reduce greenhouse gas emissions, a distinction needs to be made between the different types of emission[13]:

- **Direct or indirect emissions** linked to sludge or consumables used, to transport and to infrastructure. These include, for instance, greenhouse gases produced by gas flaring and vacuum trucks or from the breakdown of carbon and nitrogen-based matter. A further example is greenhouse gas emissions from electricity used to power a pump;

- **Avoided emissions**, which are emission reductions achieved during sludge treatment or reuse and that can include using biogas to produce electricity or thermal power, as well as recycling treated sludge to produce fertiliser, alternative fuels or mineral inputs for the cement industry.

Wastewater treatment station in Lebanon

13. ADEME, ASTEE (2018) *Guide méthodologique des émissions de gaz à effet de serre des services de l'eau et de l'assainissement.* Guide sectoriel, mise à jour 2018.

Mitigation for water services

For water production, the main greenhouse gas emitters are pumps, particularly those used to pump water up into elevated storage facilities (water towers).

Mitigation measures can cover two principle components:

Energy options

The type of energy supply system selected is a key issue for mitigation. The aim is to **opt for renewable energy sources** in order to reduce reliance on forms of energy that emit high levels of greenhouse gases, such as thermal power. The relevance of the various energy systems should be assessed in relation to the local resources available before any decision is made.

Solar pumping, an option in sub-Saharan Africa

Photovoltaic technology has considerably advanced over the last few years, leading to improved energy efficiency and lower investment and operating costs. **This option can be particularly suitable for use in countries in the Global South** as it makes it possible to meet a wide range of demands for water. The Sahel countries of Mauritania, Senegal and Mali, in West Africa, have the best solar potential in the world. It is estimated that the Sahel region receives an average of 5.5 kWh of sunshine per square metre each day over the course of a year.

Suitable for use as the only source of power on small-piped systems, photovoltaics can be combined with other energy sources on larger systems to offset periods of reduced sunlight or hourly water flow constraints (a maximum of 6 hours pumping per day on average). These hybrid systems predominantly use solar power. The secondary energy source (usually thermal power or the commercial grid) is used only to supplement the solar pumping system during peaks in demand.

Streamline systems to reduce energy consumption

In order to reduce greenhouse gas emissions, the water treatment plant needs to be appropriately sized and its performance needs to be optimised.

• Correctly design and size systems and facilities

The process of designing water supply systems usually involves factoring in an increase in water demand due to population growth or adding a margin as a technical precaution. In many instances, this can result in the installation of oversized pumps that consume more energy than necessary, reducing the length of their useful life (as they operate at a sub-optimal level). Similarly, it is also important to select the appropriate pump drive. The size of the pump required should be determined by assessing pressure losses and flows and by identifying the distribution pressure required at different points on the network.

Rather than installing oversized pumps, additional pumps can be added to keep pace with the rise in demand. Generally speaking, the best way of reducing the energy impact of pumping is to **use gravitational systems whenever possible**. The facilities selected will also have a major impact on the network's sustainability.

• Improve energy efficiency

Streamlining operations and renewing equipment can also help reduce the energy-related indirect emissions produced by treatment processes and pumping.

- Efforts could be made to optimise pumping times through energy storage by storing water (increasing the capacity of reservoirs and water towers, for example).
- Streamlining maintenance and potentially replacing equipment and vehicles with low-emission and energy-efficient alternatives could also be considered.

• Reduce indirect emissions (avoided emissions)

There are a number of options available for reducing indirect emissions from water systems, namely by preventing their production:

- Reduce water losses on the network (improve network efficiency, identify leakages) to help manage the service's energy consumption;
- Raise users' awareness of the importance of properly using and protecting the resource;
- Promote the local production of chlorine for water treatment to reduce greenhouse emissions from transport. More generally, select reagents by taking their emission factor into account. The use of these reagents can be reduced by optimising their dosage.

Mitigation for sanitation services

Sources of greenhouse gas emissions

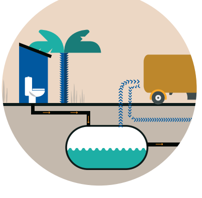
On conventional sewer systems, the largest greenhouse gas emitting activities include wastewater aeration in wastewater treatment plants and pumping in the sewers. For on-site sanitation, transporting the sludge by vacuum truck and sludge treatment processes can both produce high levels of greenhouse gas emissions.

The main greenhouse gases released are **carbon dioxide** (CO_2), **methane** (CH_4) and **nitrous oxide** (N_2O).

Gas	Production
CO_2	– When transporting pit sludge (by vacuum truck) from on-site sanitation facilities; – During wastewater treatment processes, as organic matter is broken down; – When generating electricity to power the treatment plant; – During sludge treatment: combustion or flaring of biogas, incinerating sludge on-site.
CH_4	– From septic tanks, if not regularly emptied; – When discharging sewage without treatment into watercourses; – From conventional sewers: gas emitted from stagnant sewage, open and hot sewers; – From the wastewater treatment plant: produced when anaerobic digestion breaks down organic (matter (COD treatment); – From potential CH4 leakages when producing biogas; – From wastewater discharged into the sea, rivers or lakes.
N_2O	– When discharging sewage without treatment into watercourses; – From the wastewater treatment plant: from processes used to treat nitrogen in the wastewater, (including urea, ammonium, proteins (TKN reduction); – When discharging treated wastewater into the environment, when composting or using sludge (as fertiliser; – When incinerating sludge. It is to be noted that N_2O emissions naturally occur in aquatic environments (rivers, estuaries, lakes).

14. ADEME, ASTEE (2018) *Guide méthodologique des émissions de gaz à effet de serre des services de l'eau et de l'assainissement.* Guide sectoriel, mise à jour 2018.

Prior to implementing a mitigation plan and strategy, greenhouse gas emission levels should be measured in order to identify the sanitation chain activities that produce the most greenhouse gases. This will help better assess issues throughout the value chain and prioritise interventions. By way of an example, as a result of such an exercise, the Greater Paris Interdepartmental Sanitation Authority (SIAAP) has been able to reduce its greenhouse gas emissions by 25%.



Mitigation on the 'access/collection' and 'discharge/evacuation' segments

• For the on-site sanitation chain

The mechanical collection of sewage by vacuum truck can generate high levels of greenhouse gas emissions. Thus, **optimising and reducing the distances to be travelled can significantly decrease emissions.** Courses of action can include constructing small decentralised treatment systems near to areas of housing. Conducting regular vehicle maintenance and opting for more fuel-efficient vehicles can also help keep greenhouse gas emissions to a minimum.

Another potential course of action involves **reducing the volumes of sewage to be transported** by promoting on-site treatment and the use of systems that separate the different types of human waste when appropriate (such as urine-diverting toilets for agricultural reuse or systems that separate the greywater out for treatment and infiltration through soakaways, etc.).

• For conventional sewerage

Mitigation measures can also include reducing the volumes of sewage to be treated. Raising users' awareness of the importance of conserving and saving water can help reduce the volumes of both greywater and blackwater produced by dual-flush toilets. In order to reduce the energy consumed by lift pumps, priority should be given to designing gravitational sewers.

When implementing mitigation measures, consideration should also be given to stormwater management, with separate systems for rainwater and sewage included in the service design. Where this is not the case, certain **nature-based solutions** can be used to improve the infiltration of rainwater and thus reduce the volumes of wastewater to be treated.

Mitigation on the 'treatment' segment

- **Energy options and treatment processes**

The energy consumed at wastewater treatment plants makes the treatment segment the largest emitter of greenhouse gases in the sanitation chain. Therefore, the first steps towards climate change mitigation include installing gravitational treatment systems, introducing low-emission treatment processes and using renewable energy sources.

Planted filter treatment systems

Planted filters are nature-based treatment systems that are particularly well suited for use in small towns or settlements as they use little energy and require very little maintenance compared with other treatment processes, such as activated sludge. With regard to mitigation, this is the system with the lowest energy footprint.

- **Improving pumping efficiency**

Reducing the energy-related indirect emissions produced by treatment processes or pumping will also involve reducing energy consumption, which can be achieved by:

- Streamlining operating procedures (operating hours, pumping time, etc.);
- Installing higher performance engines and adding variable speed drives to optimise consumption in real time.

Introducing a circular economy for sanitation services

Mitigation measures for the sanitation chain lend themselves well to the application of **circular economy** principles. This approach encourages a change in mindset as it regards wastewater and sanitation treatment by-products as resources.

The use of these resources should be defined in synergy with other stakeholders and services, including the energy sector, agricultural sector, and solid waste management, etc.

The resources to be considered include:

- The thermal potential of effluent: using the waste heat from the sewers for district heating or energy production;
- Producing green energy through biomass fuel systems or biogas reuse;
- Using the nutrients produced from wastewater or sewage treatment in agriculture, enabling cooperation with the solid waste sector (reusing green waste in co-composting).

The concept of a **circular economy** describes an economic model of trade and production that seeks to improve the effective use of resources and reduce our impact on the environment. *Source: ADEME*

The water sector is particularly well suited to transition to a circular economy as wastewater treatment by-products can be used for agriculture or to produce energy.

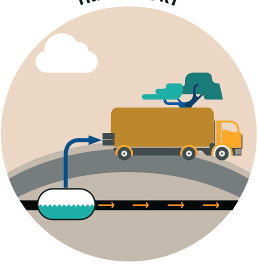
In order to develop a circular economy, an enabling environment for implementing new practices and changing mindsets is required to ensure sanitation by-products are seen as resources. To be economically viable, the use of these by-products needs to meet a demand (which can be stimulated) and this can often create issues of scale. Various courses of action can be taken to foster this approach, particularly with regard to regulation and the market economy.

Figure 4: An illustration of some mitigation options along the sanitation chain

COLLECTION

Reduce the volumes of sewage to be treated to reduce pump energy consumption, reduce dilution and condense effluent: separate greywater and stormwater, divert urine, raise users' awareness to reduce waste, etc.

TRANSPORT



ON-SITE SANITATION

Reduce the distances to be travelled by vacuum trucks by introducing decentralised treatment plants.

Maintain the fleet of vehicles in good working condition (preventive maintenance and replacing parts) to ensure the optimum performance of the vacuum trucks and minimise pollution.

Replace the oldest vehicles and largest GHG producers.

SEWERS

Reuse the waste heat from sewage to produce hot water or in treatment processes.

TREATMENT

Treatment processes: opt for energy recovery or low energy consuming processes (to reduce GHG emissions).

Wastewater treatment plants (WWTP):

- Install **gravitational systems** and introduce extensive treatment methods in areas where land is available.
- **Use local materials** to reduce transport emissions.
- Use **'green' energy sources**: solar, wind (and heat recovery from treatment processes).
- Where no reuse is possible for GHG emitting processes, **burn off the gases through flaring**.

REUSE

Reuse the gases produced: harness and use the methane produced at the WWTP and through local reuse (biogas), Co-generation (heat + electricity)

Recycle urine (collection at source and reuse): no need to treat nitrates (reduction in energy-intensive processes at the WWTP); blackwater is less diluted (better for biogas); can be used as fertiliser, eliminating the need to buy chemical fertiliser from outside the local area and produced using environmentally unfriendly processes.

Reuse wastewater for agriculture: to replace pumped water for irrigation. Dried sludge: potential for use as a heating material.Promote the local spreading of sludge as fertiliser.

6. Conclusion

Climate change and its impacts can be seen in many regions around the world and is having a major effect on the large water cycle: rising sea levels, disrupted seasonal rainfall patterns, a rise in average global temperatures, droughts, heatwaves and more frequent extreme weather events.

These climate-related hazards have repercussions for the availability and continuity of water and sanitation services not only because of falls in both the availability and quality of water resources but also because of the direct impacts these hazards have on the various service components (infrastructure and facilities, service operations and quality, etc.). This exacerbates the existing vulnerabilities caused by population growth and urbanisation. The health, social and economic impacts can be severe, particularly in developing countries and for the poorest or most exposed communities.

Thus, it is vital to take climate change and its impacts into account when developing water and sanitation services. This is especially urgent as inaction will increase future risks. A sound understanding of the impacts and issues is required before taking action, which in turn should be linked to the overall objectives of national and international frameworks and agreements (Paris Climate Agreement, SDGs, the Sendai Framework, etc.).

Adaptation and mitigation are two complementary approaches to tackling climate change that can give rise to a range of responses for reducing the vulnerability of services. Thus, a paradigm shift in priorities and practices is required in order to manage the uncertainties inherent in climate change scenarios and avoid mal-adaptation.

Implementing adaptation or mitigation measures involves integrating climate risks into all approaches and at all levels. To facilitate implementation, an initial assessment phase should be completed to determine local and river basin vulnerability, exposure and level of risk for each hazard.

The measures selected should include concerted and multi-sector approaches, as well as no-regret options. Existing approaches, such as integrated water resource management, nature-based approaches, water safety management plans, or the concept of the circular economy can be used to inform the development of appropriate and sustainable responses.

Finally, the monitoring of initiatives and sharing of experiences among stakeholders should be strongly encouraged, as should climate change impact research. Without these activities, promoting and improving practices will not be enough to produce long-term responses.

Appendices

Appendix 1: 'Water' Scenario

The fictive scenario of a water service affected by climate change and its impacts outlined below provides a tangible illustration of the proposals set out in this guide. The full, and more detailed, case study is available at: **www.pseau.org/fr/eau-et-changement-climatique**

Description of the water service

Rococo is a rural community of 5,000 inhabitants located in the Sahel region. Its economy is based primarily on agriculture and livestock. The population is growing by between 2 and 3% per year.

The water supply system: the village has a water supply system that distributes water to 30 private connections, 6 standpipes and 3 public connections (a school, a health centre, and a place of worship). Water is pumped from the aquifer through two 60 metre deep boreholes, each fitted with an electric pump powered by a generator. A 50m^3 capacity water tower is used for storage and gravity distribution. Less and less water is being extracted as low rainfall and droughts are reducing groundwater recharge. As a result, there are service interruptions every two days. Most inhabitants have reduced their consumption and use alternative water sources (particularly pastoral wells) when the service is disrupted, which generates serious health risks. Thus, fewer people have access to a basic service (SDG definition) and inhabitants have to travel greater distances to fetch water. The lack of water is being exacerbated by an increase in demand.

Water service assessment

Climate-related hazards	Increase in the length of droughts and the variability of seasonal rainfall patterns.
Exposed areas	Land in the village/local authority area/river basin.
Potential impacts	Weakened pumping equipment Temporary service interruptions Decreased revenue, and financial insecurity Use of alternative water points that do not provide sufficiently safe water.
Vulnerability of the water supply system	The vulnerability of the system is enhanced by the increase in demand for water (particularly during the dry season) and the lack of technical and financial resources available for network maintenance.

Production of GHG: the (diesel) thermal pumping system generates high levels of GHG and has a high operating cost.

Courses of action (at the local authority and the village levels)

Adaptation measures / mitigation measures

Contracting Authority	– Climate change adaptation becomes a priority at the municipal level. The local authority embarks on a process to assess its vulnerability to climate change and its impacts, focusing specifically on the water service. – The local authority develops a water resources data-sharing and monitoring system for the municipal area or in cooperation with the municipalities surrounding the river basin.
Awareness-raising (IEC)	– Set up an awareness-raising campaign on protecting water resources (covering topics such as protecting spring catchment areas, encouraging farming practices that incorporate stormwater infiltration, eliminating open defecation).
Planning	– Develop a municipal climate change adaptation plan, which is aligned to a broader river basin-level adaptation plan. – Connect the water supply systems of neighbouring villages together to share the use of high-flow boreholes. – Plan to construct hillside reservoirs and micro-dams to improve groundwater recharge.
Study Phase + Construction/Procurement Phase	– Systematically carry out impact assessments. – Increase the storage capacity of the water tower and optimise the energy efficiency of the pumping system. – In time, replace the electricity generators (which are costly and emit GHG) with solar pumping systems.
Technical and Financial Monitoring and Operations	Implement a monitoring system to monitor: rainfall, access to the service and consumption, the condition of the infrastructure, and economic and financial indicators.

Appendix 2: 'Sanitation' Scenario

A fictive scenario of a sanitation service affected by climate change and its impacts is provided below. The full, and more detailed, case study is available at: **www.pseau.org/fr/eau-et-changement-climatique.**

Overview of the situation:

Located in a country in the Sahel, Sanibougou is a secondary town of 150,000 inhabitants that is experiencing rapid urban growth. A significant portion of the town's population has smallholdings and families farm the land around the town to grow grain. Families have household latrines, which have been built in a variety of different ways. The municipality provides a pit-emptying service, using a vacuum truck that is over 20 years old. The pit sludge is disposed of in drying beds. Once dry, it is stored nearby and made available to farmers. During rainfall events, water flows down the preferential channels that form in the laterite roads and into household plots. Substantial volumes of water flow into the poorest neighbourhoods, which then flood. There is a technical vocational training centre in the town. Nearly 1,000 students live in Sanibougou all year round.

Assessment of the situation through the lens of climate change

First climate-related hazard: drought (see the full case study on the internet)

Second climate-related hazard: extremely heavy and irregular rainfall

Exposed areas	Neighbourhoods built on impermeable soils and in low-lying districts.
Potential impacts	– Poorly designed latrines are destroyed – Latrine pits are flooded and wastewater overflows onto public roads – Pit emptying services are disrupted as some areas become inaccessible – Sludge treatment processes in the drying beds are disrupted due to rain.
Vulnerability	– High for the sanitation service; – High for the population because of the potential health impacts.

Courses of action

NB: measures should respond to all the climate-related hazards assessed, namely droughts and extremely heavy rainfall events. Other measures, such as awareness-raising, are not covered here but are included in the full case study available online.

Adaptation measures / mitigation measures

<table>
<tr><th></th><th>Access</th><th>Evacuation/ Transport</th><th>Treatment</th><th>Reuse</th><th>Stormwater Management</th></tr>
<tr><td>Contracting Authority</td><td>Sanitation becomes a municipal priority (a subsidy is introduced to enable the poorest households to install latrines that can withstand heavy rains).</td><td>Set up certification for pit-emptying operators that includes a vehicle technical inspection.</td><td></td><td></td><td>The municipality develops a climate-hazard monitoring system (collecting, processing and sharing data).</td></tr>
<tr><td>Planning</td><td>Set an ambitious but achievable household sanitation facility coverage target.</td><td>Increase the number of sludge disposal and drying sites to reduce the distances to be travelled.</td><td></td><td></td><td>The municipality adopts a restrictive policy on the location of new buildings and a stormwater management infrastructure investment plan.</td></tr>
<tr><td>Study phase</td><td>Install alternative types of latrine (watertight pits) in areas vulnerable to flooding.</td><td></td><td colspan="2" rowspan="2">Select[15] a reuse technique for treatment of the by-products: a biodigester, which produces biogas for use in the vocational training centre kitchen.</td><td>Drainage systems in high risk areas are designed with specific dimensions.</td></tr>
<tr><td>Construction/ Procurement Phase</td><td>Increase quality inspections of newly constructed latrines.</td><td>Replace the vacuum truck with a more fuel-efficient vehicle.</td><td></td></tr>
<tr><td>Technical Monitoring Phase and Service Operations</td><td>Conduct regular analyses of collapsed or overflowing latrines to identify and address their shortcomings.</td><td>Empty pits more regularly to ensure pits do not become too full and to reduce overflowing.</td><td>Train the drying bed operators to improve their monitoring of the dry-solid content of the sludge.</td><td>Increase awareness of sludge spreading (as rain disrupts the sludge drying process).</td><td>Specific monitoring is conducted to determine the surface area of areas regularly at risk of flooding.</td></tr>
</table>

15. This is a 'no regret' option that forms part of a long-term vision while also meeting sustainability requirements as the training centre will ensure there are skilled people available locally to operate this treatment system.

Annexe 3 : Glossary

Adaptation	Climate change adaptation is defined as the process of adjustment to actual or expected climate and its effects. In human systems,adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. *Source: IPCC, 2014*
Circular economy	The concept of a circular economy describes an economic model of trade and production that seeks to improve the effective use of resources and reduce our impact on the environment. Source: ADEME
Climate related hazard	A climate-related hazard is the potential occurrence of an event that may cause loss of life or injury, as well as damage and loss to businesses, services and the environment. This can be an extreme weather event or a longer-term trend. Source: Seine-et-Marne, 2015
Exposure	Exposure is the presence of a human or natural element (people, species, ecosystems, environmental functions, economic activities, etc.) in places or settings that could be adversely affected. Adapted from:IPCC, 2014
Impact	Impact is the effect that a climate-related hazard has on natural and human systems. These effects manifest themselves locally on people's lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure. Impacts are also referred to as consequences and outcomes. Adapted from: IPCC, 2014
Mal-adaptation	The concept of mal-adaptation is used to define a change made to human or natural systems to address climate change that (unintentionally) increases rather than reduces vulnerability. Source: Ministry for Ecological and Inclusive Transition
Mitigation	Mitigation refers to activities that seek to minimise the scale of climate change by reducing direct and indirect greenhouse gas emissions. Adapted from: ADEME, 2012
Nature-based solutions	Le concept d'économie circulaire désigne un modèle économique d'échange et de production qui vise à augmenter l'efficacité de l'utilisation des ressources et à diminuer notre impact sur l'environnement. Source : ADEME

No-regret option	An action that reduces vulnerability to climate change and continues to have benefits under all future climate scenarios. Source: Seine-et-Marne, 2015
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and transformation. Source: IPCC, 2014
Risk culture	This means that all stakeholders (elected officials, technical staff, the general public, etc.) are aware of natural phenomena and understand vulnerability. Informing people at an early age is the key driver for advancing risk culture. Source: Ministry for Ecological and Inclusive Transition
Systemic approach	A systemic approach adopts an overall approach to addressing problems or systems by examining and focusing on the interplay between their various -elements. Source: IAU ARENE, 2018
Vulnerability	Vulnerability describes the propensity or predisposition to be adversely affected. It encompasses a variety of concepts, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerability can therefore be shaped by a range of factors: socio-economic inequalities, local urban development, the implementation of adaptation strategies, etc. It is thus linked to an area's political strategies and decisions. Adapted from: IPCC, 2014

Appendix 4: Bibliography

This guide has been developed by building on the findings of a pS-Eau-facilitated working group that has been examining WASH services and climate change since 2015, as well as on analysis of the reference documents listed below.

Supporting documents

ADEME (2012) ***Le changement climatique. Comprendre les phénomènes, les anticiper et s'y adapter.***

ADEME (2013) ***Monitoring and Evaluation (M&E) Method for Climate Change Adaptation Policies, Methodological Guide.***

ADEME, ASTEE (2018) ***Guide méthodologique des émissions de gaz à effet de serre des services de l'eau et de l'assainissement. Guide sectoriel, mise à jour 2018.***

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pS-Eau (2018) ***The Sustainable Development Goals for Water and Sanitation Services - Interpreting the Targets and Indicators.***

United Nations (2015) ***Paris Agreement.***

United Nations Economic Commission for Europe (2009) ***Guidance on Water and Adaptation to Climate Change.***

UN-Water (2018) ***Nature-based Solutions for Water. UN World Water Development Report 2018.***

Toolkit

Strategic Framework for WASH Climate Resilience (GWP, UNICEF)
This strategic framework is intended for all WASH sector practitioners. It provides guidance on the main areas to be considered when planning and implementing actions to develop climate change resilient WASH services.
Available at: *www.gwp.org/en/WashClimateResilience/ (in English only. Summary in French)*

CEDRA tool (Climate change and Environmental Degradation Risk and Adaptation Assessment) (Tearfund)
CEDRA is a strategic-level environmental risk assessment for use in developing countries.
Available at: *https://learn.tearfund.org/themes/environment_and_climate/cedra/ (in English only)*

CityStrength Diagnostic (the World Bank)
This tool, developed by the World Bank, sets out the steps involved in conducting a rapid diagnostic to help cities improve their resilience to a variety of shocks. The diagnostic consists of a qualitative evaluation that takes between 4 and 6 months to complete.
Available at: *www.worldbank.org/en/topic/urbandevelopment/brief/citystrength (in English only)*

CRiSTAL tool (Community-based Risk Screening Tool – Adaptation and Livelihoods) (IUCN, IISD, Helvetas, SEI)
CRiSTAL is a project-planning tool that helps users design activities that support climate change adaptation at the community level. It helps users to recognise climate risks and identify livelihood resources most important to climate adaptation.
Available at: *www.iisd.org/cristaltool/ (in French and in English)*

ECAM tool (Energy Performance and Carbon Emissions Assessment and Monitoring tool) (ICRA, IWA, GIZ WaCCLim project)
The ECAM tool is designed for assessing the carbon emissions and energy consumption of the urban water and wastewater cycle.
Available at: *www.wacclim.org/ecam/ (in English only)*

CEPRI Guides (European Center for Flood Risk Prevention)
CEPRI offers a range of guides on understanding and improving the management of flood risks. These guides include ‘Raising the Awareness of People At Risk of Flooding’ and ‘Anticipating and Predicting Floods’.
Available at: *www.cepri.net/publications-et-documents.html (in French only)*

Objectif Climat (ADEME)
ADEME has developed a methodological kit for monitoring and evaluating climate change adaptation policies, which includes a methodological guide and IT tool (spreadsheet). Available at: *www.ademe.fr/en/node/138510 (in French and in English)*

The UKCIP Adaptation Wizard v4.0 (UKCIP, Oxford, 2013)
UKCIP Adaptation Wizard is a risk assessment-based adaptation tool that provides a complete step-by-step process for developing and implementing a climate change adaptation strategy. Available at: *www.ukcip.org.uk/wizard/ (in English only)*

You can find this list with all download links as well as additional references at
www.pseau.org/en/wash-climate-change

Programme Solidarité Eau (pS-Eau) is a French multi-stakeholder network that works to ensure the availability of water and sanitation for all and the sustainable management of water resources in developing countries (the SDG 6 targets). With a focus on supporting local stakeholders, pS-Eau has been fostering information-sharing and dialogue between decentralised cooperation and non-governmental stakeholders for over 30 years. Working both in France and abroad, pS-Eau produces knowledge, supports local initiatives and promotes cooperation within the water and sanitation sector. The aim of pS-Eau's activities, which are led by a multi-skilled team, is to increase the number and quality of decentralised and non governmental cooperation projects in the WASH sector in developing countries. pS-Eau is supported by the French Agency for Development, the French Ministry for Europe and Foreign Affairs, the French Biodiversity Agency, Water Agencies and numerous regional and local authorities.

TOOLS & METHODS

WASH Services and Climate Change

Impacts and Responses

Climate change and its impacts can be seen in many regions around the world and is having a major effect on the large water cycle, resulting in rising sea levels, disrupted seasonal rainfall patterns, a rise in average global temperatures, droughts, heatwaves and more frequent extreme weather events.

These climate-related hazards have repercussions for the availability and continuity of water and sanitation services. Existing vulnerabilities caused by population growth and urbanisation mean that the health, social and economic impacts can be amplified in a context of climate change, particularly in developing countries and for the poorest communities.

It is thus vital to take climate change and its impacts into account when developing water and sanitation services. This is especially urgent as inaction will increase future risks. To this end, adaptation and mitigation are two complementary approaches to tackling climate change that can be used to provide a range of responses for reducing the vulnerability of services.

A sound understanding of the climate risks and the health, social, environmental and economic impacts is required before taking action. This guide provides an overview of the issues, along with definitions and keys to understanding the main climate-related concepts, in order to help water and sanitation stakeholders integrate these aspects into their practices.

Scan the QR code to download the guide

More information:
www.pseau.org/en/wash-climate-change

pS-Eau

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