Project report - KreATiw

Climate resilience, sanitation and water safety

Klima**re**silienz, **A**bwassersicherheit und **Tr**ink**w**assersicherheit (KreATiw)

BMBF Water Security in Africa (WASA)

Initial Phase 12/2021 – 02/2023

Reference No. 01DG21056A/B

Bettina Rickert (German Environment Agency, UBA)

Laura Huber (German Environment Agency, UBA)

Friederike Brauer (German Water Centre, TZW)

Sebastian Sturm (German Water Centre, TZW)

Tanja Vollmer (German Water Centre, TZW)

Matthew Damons (Emanti Management)

Thabisa Manxodidi (Emanti Management)

SPONSORED BY THE

Federal Ministry of Education and Research

Table of contents

Problem description

Water Safety Planning (WSP) is a preventive risk assessment and risk management approach from catchment to consumer, recommended by the WHO since 2003 with the goal to provide safe drinking water and effectively control water-related physical, chemical and microbial hazards. In 2015, the Sanitation Safety Planning (SSP) was published, which allows for risk management to be applied to sanitation settings. While the WSP approach has been widely applied globally in large and small systems and considered in regulations, SSP has been applied to a much lower extent, and to date, only 1 case of a combined WSSP appears to have been published. Consideration of an integrated water management approach (i.e. effective water supply and sanitation management) is essential for the sustainability of a healthy catchment as ineffective sanitation management will have a direct impact on drinking water supplies.

Most Southern African countries' sanitation systems include off-site sanitation (centralised sewer system connected to wastewater treatment plants) and on-site sanitation (e.g. decentralized systems such as septic tanks, conservancy tanks, ventilated improved pit latrines), or a combination thereof. For a holistic approach to be successful, it needs to consider all types of sanitation and all components of the sanitation value chain (collection, emptying, transport, treatment, end use/disposal).

By way of example, in South Africa, wastewater risk abatement planning (W_2RAP) is required for sewered wastewater systems, i.e. the national regulator, Department of Water and Sanitation (DWS) has obliged all 144 water services authorities (i.e. municipalities) to have a WSP and a W_2RAP developed and implemented. The W_2RAP process, however, rarely considers on-site sanitation, which serves roughly 30 % of the population. It is therefore important to develop a more comprehensive understanding of the on-site sanitation situation, and ensure that such is included within risk management approaches adopted by municipalities/water utilities.

Another tool that has been applied globally, including South Africa, is the Shit Flow Diagram (SFD) which helps to understand and communicate how excreta physically flow through a specified area. However, they do not yet include information on climate resilience.

Due to increases in temperature, floods, storms and droughts, municipalities in South Africa are increasingly experiencing challenges related to water quality, water quantity, and damaged infrastructure. Water resources are fundamental to the provision of drinking water, and it is therefore crucial that both drinking water supply and sanitation systems have the resilience and capacity to mitigate both current levels of climatic variability and future climate change impacts. However, it is noted that as South Africa is a developing economy, addressing service delivery backlogs and the need for socio-economic development will often take precedence over emerging issues (such as climate change). Climate change is already impacting municipalities in a way that significantly challenges their ability to sustainably and reliably provide safe drinking water and sanitation services, and is only likely to worsen over time. It is therefore essential that municipalities and stakeholders are made aware of climate variability, climate change, climate impacts which can support decisions that allow them to adapt and enhance resiliency. Most municipalities in South Africa have realised that planning is key in preparing for the future, and risk management approaches such as WSP and W_2RAP provide municipalities with a proactive, flexible and robust approach to assess and manage current and future risks (both climate and non-climate related). However, it is often challenging for

municipalities to understand the relevance of climate information, interpret the information and incorporate the findings into existing risk management processes and day-to-day activities. These processes often do not consider a holistic integrated water management approach.

Objectives

Within the BMBF-funded KreATiw project, the Umweltbundesamt (UBA), TZW: DVGW Technologiezentrum Wasser and Emanti Management aim to (1) refine and test an approach to integrate climate variability and change into existing water and sanitation safety planning approaches for a holistic integrated water risk management approach, and to (2) grow and develop capacity that enables the roll-out of the approach throughout Southern Africa.

The initial phase of the project lasted from December 2021 until February 2023. Within this phase, the project team compiled data and information from Southern Africa on access to drinking water and sanitation services, risk-based approaches and regional experiences with them, regulation of drinking water and sanitation services and risk management, sources of climate data and their usefulness, existing capacity building approaches and monitoring concepts related to risk-based approaches. The data analysis focused on the six countries of the *Water Security in Africa* call: Angola, Botswana, Namibia, South Africa, Zambia and Zimbabwe. The results presented in this report will be the basis for works during the project's main phase. The activities focused on information from Southern Africa with a special emphasis on South Africa and included some information on Germany to illustrate existing experiences and options to transfer the project's results. In addition, the project team identified and engaged with relevant stakeholders in Southern Africa and Central Europe as well as with potential pilot sites. Moreover, the team worked at ensuring capacity building and knowledge transfer through the cooperation with academic institutions and the publication of project results.

Methods

Data sources used to gather information on safe access to drinking water and sanitation and regulatory settings in Southern Africa are the UN-Water Global Analysis and Assessment of Sanitation and Drinking Water (GLAAS) data portal (WHO 2022a), the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) WASH data portal (WHO/UNICEF 2022) and the regional report on the Status of the Water Supply and Sanitation Regulatory Landscape across Africa of the Eastern and Southern Africa Water and Sanitation Regulators Association (ESAWAS 2022).

For South Africa, the approaches and latest reports on the Blue Drop and Green Drop Certification Programmes and experiences with the approaches of WSP, W_2RAP as well as SFDs and related publications were considered to document the status of experiences with risk management approaches in Southern Africa. In addition, a literature review was conducted by searching the databases of Scopus, ScienceDirect and Google Scholar. Climate information sources and data on current and projected climate were summarised based on experiences from South Africa and respective publications.

Results

1. Baseline Analysis

The JMP database offers data on access to drinking water and sanitation. Since there are no country estimates on safely managed services for most countries, the data on the safest, hence best service level available is data on access to basic services. The coverage of at least basic drinking water services in Southern Africa ranges from 57 % (Angola) to 94 % (South Africa), according to JMP data from 2020. For sanitation, the coverage with at least basic services is lower, ranging from 32 % (Zambia) to 80 % (Botswana). In order to reach equitable access to safe drinking water and sanitation for all by 2030 the majority of the countries has to drastically increase their annual rates of change. Overall, the data reveals great inequities in drinking water and sanitation coverage between the poorest and richest population, and between urban and rural areas in Southern Africa. With exception of South Africa, the greatest deficits and therefor need for action in all countries remains the coverage of sanitation services for the poorest population living in rural areas. In most cases, lower coverage and lower quality of service correlate with the use of non-piped systems and on-site sanitation, which are predominantly used in rural areas. (WHO/UNICEF 2022)

This shortcoming is also reflected in existing regulation of water and sanitation services, which mainly focuses on piped water supply and sewered sanitation. There is a severe need for improvement regarding developing and applying regulations for household water supply sources and point water sources. So far, more progress has been made in the regulation of water supply than for sanitation services. Other pressing weaknesses exist in the regulatory environment for water supply and sanitation service delivery in most Southern African countries concerning autonomy, participation, and transparency. (ESAWAS 2022)

One option to strengthen drinking water and sanitation safety through regulation is to obligate the implementation of risk-based management approaches such as WSP, SSP and W_2RAP. While WSP is a tool to assess and manage risks in the water supply system, from catchment to consumer, SSP and W_2RAP are risk-based approaches to identify and prioritise health risks along the sanitation value chain. Although some Southern African countries are including risk-based approaches for drinking water and sanitation in national regulations, and consider climate change preparedness in their national planning, not all of them have implemented the associated policies (WHO 2022a). In South Africa, the implementation of a WSP and a W_2RAP is a requirement of the Blue and Green Drop Certification Programme which is an incentive-based regulation. The Blue and Green Drop programmes assess the water and sanitation services businesses, to ensure the provision of safe water and the adoption of best practice towards continued improvement aiming (DWS 2022a, 2022b). Another option would be to include SFDs into regulation, which is used to visualise service outcomes in terms of the flow and fate of human excreta in a defined area (municipality/city). The visualisation is easily understandable and therefore serves as a tool to engage relevant stakeholders, including those without extensive expertise on the wastewater transport and treatment system (Roeder 2016).

Including climate resilience into risk-based approaches aims at ensuring continued sustainability of safe drinking water and sanitation under current and future climate conditions. The latest editions of the WHO WSP and SSP Manuals as well as the WSP field guide integrate the consideration of climate resilience (WHO 2022b, 2022c, 2023). Our literature review highlights that there is only a limited number of publications on WSP/SSP considering climate

aspects in Southern Africa. The results also give reason to assume that there is more research being done on risk management in the drinking water sector than in the sanitation sector.

Within the project, the current and projected climate in Southern Africa and existing sources of climate information were analysed. From 1991 to 2021, a continuing trend with a mean temperature increase of 0.2 °C has been observed in Southern Africa. This trend is projected to continue, while precipitation is expected to decrease in the future. These trends are projected to amplify negative impacts on water supply and sanitation services resulting in increased risk of climate related hazardous events. (Archer *et al.* 2018)

Understanding of the current and projected local climate context enables the WSP/SSP/W_2RAP teams to incorporate climate resilience into the risk-based processes. To gain said understanding, broad research is necessary. Since many data sources require a certain level of expertise, it may be advisable to include data analysis experts to support the teams. Climate information can be accessed through working with stakeholders, locals or expert groups, climate reports, web-based tools or the analysis of historical climate-related data. However, for small systems it may be challenging to access respective expertise, and a simplified approach or providing data specifically aggregated for their needs could be feasible. The reviewed data shows a varying extent and level of detail between the Southern African countries. In South Africa, extensive climate data is available at the local level, including details on projected climate-related risks.

In order to monitor and quantify the success of the implementation of the approach at the pilot sites, credible and reliable performance indicators need to be assembled. These indicators should meet a set of criteria including objectivity, simplification of complex analysis, and clarity. In addition, they need to be appropriate for all municipalities/utilities involved. As a basis, existing concepts for indicators were analysed, for example the WHO WSP outcome evaluation (unpublished) or the USAID Resilient Waters Program indicators (USAID 2021). The team developed a set of indicators covering all steps of the approach which can be found in Annex 2: List of performance indicators. The objective of the use of these indicators is to track the pilot sites' progress by applying them before and after the piloting of the holistic approach.

To enable Water and Sanitation Services Authorities to implement risk-based approaches, it is necessary to offer training that supports capacity building. A number of freely available training materials already exist for WSPs, including from WHO, and to a limited extent for SSPs. Materials on integrated water and sanitation safety plans (iWSSP) are currently being developed, however, no published training materials on iWSSP, as well as on integrating climate aspects into these risk management approaches have been published to date. Experiences with training and capacity building on WSPs suggest face-to-face training and online / blended training as formats, and emphasise the importance of translating the materials into the local language and adapting it to local circumstances.

The project team plans to: (i) conduct trainings for the pilot sites on the implementation of the CR-WSSP approach, (ii) facilitate pilot site implementation, (iii) support pilot sites in fundraising for improvements, (iv) develop courses and vocational training on the approach, (v) advocate the use of climate information and the need for CR-WSSP for university students, and (vi) develop training materials and online courses that will be used for the broader roll-out of the approach. In detail, the team plans to distribute the gained knowledge and training materials through an online platform, webinars, presentations at international congresses, and publications. This activity will be supported by several internationally working organisations.

In Germany, the implementation of WSP will become legally binding shortly. Although there is already some experience with WSP, there is no experience with SSP. The project outcomes will therefore be beneficial in making the German drinking water and sanitation sector more resilient to climate variability and changes, and paving the way for scaling up risk-based approaches in the future.

2. Identification and involvement of relevant stakeholders

The project team contacted the following stakeholders in Southern Africa and Central Europe to discuss their possible involvement in the project and identify pilot sites (Table 1, Figure 1).

Table 1 List of stakeholders

Located in	Stakeholder
South Africa	Breede Olifants Catchment Management Agency (BOCMA)
	Department of Water and Sanitation (DWS)
	German Embassy in South Africa
	Stellenbosch University International, Stellenbosch University Water Institute
	Viva con Agua South Africa
	Water Research Commission (WRC)
Zimbabwe	UNICEF Zimbabwe
	Welthungerhilfe
Namibia	Namibia University of Science and Technology
	UNICEF Namibia
Angola	Water Directorate of Angola
Zambia	University of Zambia
	WHO Country Office
Botswana	University of Botswana
Southern Africa	WHO Regional Office for Africa
Germany	Autorenkombinat
	Gelsenwasser
	GIZ
	Holinger
	inter3
	TU Berlin
	Viva con Agua e.V.
	Zukunft – Umwelt – Gesellschaft (ZUG) gGmbH
Netherlands	Faecal Sludge Management Alliance

The meetings were mainly held virtually. In March 2022, meetings were held in presence with the Villiersdorp and Theewaterskloof Municipalities, BOCMA, City of Cape Town, DWS, WRC, Stellenbosch University and the German Embassy in South Africa. In September 2022, further on-site meetings were held with Chris Hani District Municipality, Stellenbosch University and BOCMA. During the meetings, several possible pilot sites were identified and the framework for future cooperation was discussed. In January 2023, further meetings were held in presence with Stellenbosch University and Viva con Agua to finalise details of the future collaboration.

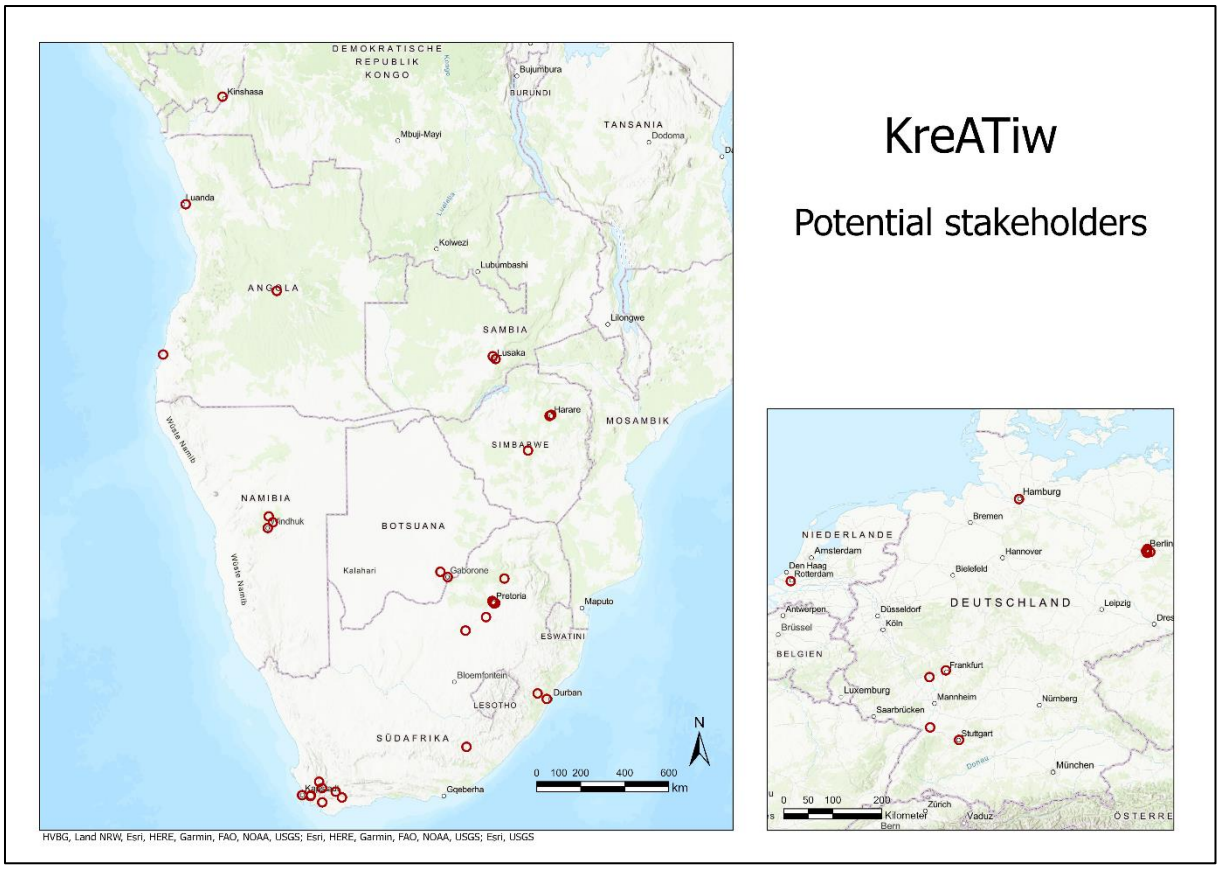

Figure 1 Map of potential stakeholders

The stakeholders contacted agreed to support the team in the activities of capacity building, supervision of students, the piloting process and dissemination of learning materials, and showed their commitment to their planned participation in the project in the form of letters of intent.

3. Identification of pilot sites

In order to test the holistic CR-WSSP approach the team engaged with municipalities and organisations which are in contact with potential pilot sites in South Africa, Angola, Namibia and Zimbabwe. The team directly contacted several sites and were put in contact with additional sites through GIZ, Viva con Agua South Africa, UNICEF and BOCMA.

The team developed 3 questionnaires to compile information on each site and used the results to identify and choose a set of pilot sites reflecting a range of different settings. The questionnaires cover the three aspects (1) organisation and climate change, (2) drinking water

and (3) sanitation. They were completed for 33 drinking water systems and 27 sanitation systems. They were handed in for a total of 13 local/district municipalities covering 60 different drinking water and sanitation systems (Figure 2).

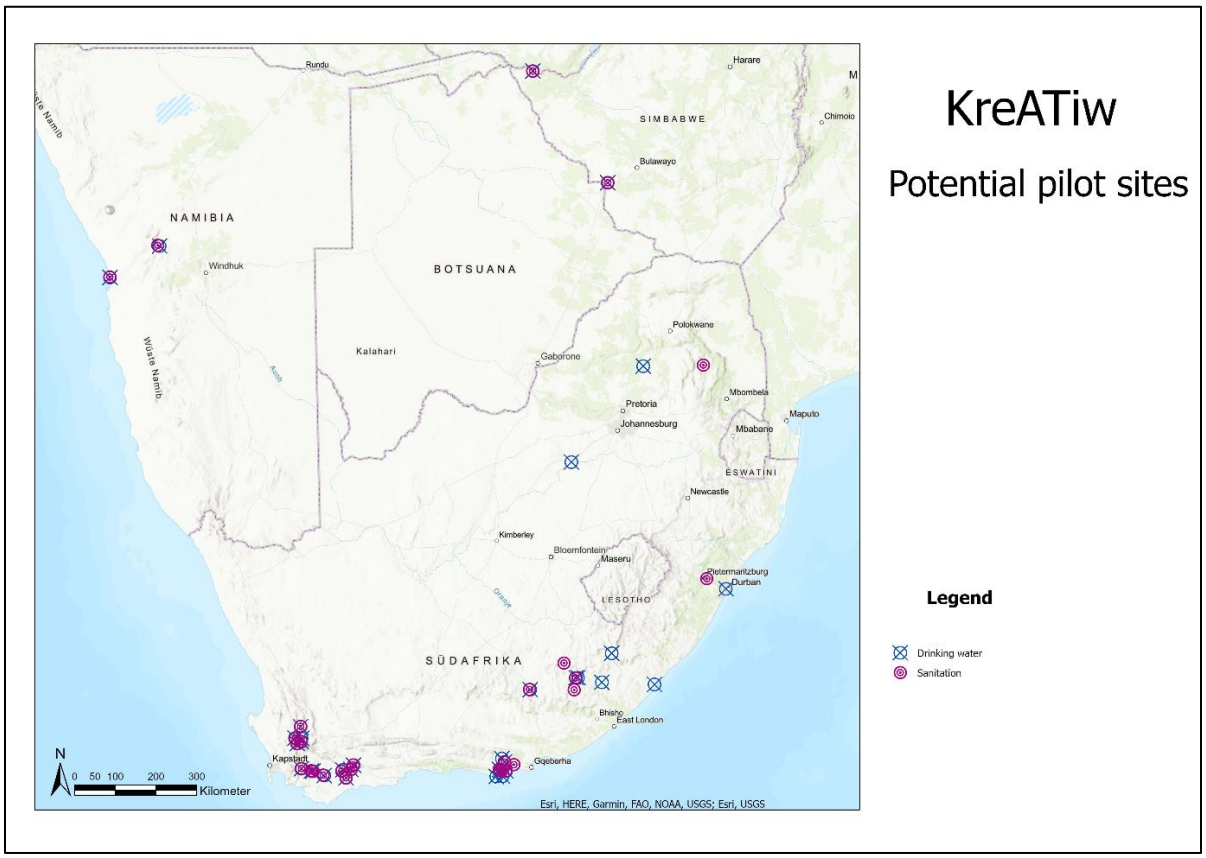

Figure 2 Map of potential pilot sites

As a result of the compilation of questionnaires, the following points can be stated:

- All 13 local/district municipalities have experienced climate-related issues affecting their water and/or sanitation system.
- The most commonly mentioned climate-related issues are droughts, followed by floods. Other climate-related impacts are algal blooms, wild fires, sea level rise, increased temperature and extreme weather events leading to landslides.
- 10 of them are currently using climate data in their decision-making.
- Key expectations noted by the potential pilot sites include:
  - Sustain the treatment plants and water source despite impacts of climate change
  - Learn and share knowledge with other utilities
  - Improve existing WSP
  - Raise awareness on climate change within municipality and community
  - Enabling to use climate data
  - Improve service delivery to public, operation of sites and risk management
  - Gain knowledge regarding climate change adaptation at treatment plants
  - Increase climate resilience
  - Understand the vulnerabilities of the systems

The team chose 6 main pilot sites in South Africa which differ in size, type of drinking water source, type of wastewater treatment and experience with risk management. The team plans

to visit these sites and to include them in on-site workshops during the main phase of the project.

In order to include the rest of the sites in the piloting of the approach the team plans to develop self-study material which can be accessed by them and refined through their feedback. The experiences from the implementation accompanied by on-site workshops and the autonomous implementation of the rest of the sites will be used to refine the approach and training materials which will support the greater roll-out of the approach.

4. Cooperation and knowledge transfer

On 30 September 2022, the team held a workshop at the biennial Water Institute of Southern Africa (WISA) conference and exhibition in Sandton, Johannesburg. The WISA conference invited regional and international professional audiences, companies, regulators and stakeholders in the water sector to exchange views on developments in science, technology, policy and practice under the theme "Navigating the Course". In addition to establishing contacts with other stakeholders, the workshop served capacity building purposes. Among other things, the impact of climate change on water supply and sanitation, possible risk management approaches and the integration of climate information were presented. Participants of the workshop, including representatives of the South African DWS and the WRC, expressed their interest in discussing possibilities of cooperation in the main phase in further talks.

To strengthen knowledge sharing and to ensure capacity building in the main phase, the team organised further meetings with Stellenbosch University, TU Berlin, UNICEF, WHO Regional Office for Africa and GIZ. In addition, with the support of WRC, the team organised a webinar on 19.08.2022, which was attended by 70 participants. The team plans to develop and implement courses for students and practitioners in cooperation with Stellenbosch University. Furthermore, it was discussed whether doctoral or master's theses could be offered in cooperation with TU Berlin, Stellenbosch University and other universities of the AUDA-NEPAD network.

5. Main phase

Besides engaging with potential project partners and pilot sites, and the development of the indicator list and capacity building approaches, the main project result and basis for the activities of the project main phase is the development of the holistic approach.

By combining the approaches WSP, W_2RAP, SSP and aspects of climate resilience, KreATiw developed a holistic climate-resilient water and sanitation safety planning approach (CR-

WSSP) which aims at supporting municipalities of different sizes and diverse settings in assessing and managing current and future risks and in becoming more resilient. The research and engagements conducted by the KreATiw team during the initial project phase illustrate that there is little experience in including aspects of climate resilience in risk-management of water and sanitation services and emphasizes the importance of and local interest in this holistic approach.

In 2019, the WRC with the support of Emanti Management initiated a project to develop an implementation guideline for incorporating climate resilience into WSPs and W_2RAPs (WRC 2022). The guideline provides users with a comprehensive list of climate-related data/information sources, and a methodology to draw basic climate impact conclusions that are useful to risk management. The methodology was piloted in several South African municipalities, which had recently been affected by climate change impacts.

The methodology highlights:

- the need to consider various climate data and information sources,
- collecting, collating, and summarizing the information,
- updating and refining WSPs and W_2RAPs to incorporate climate considerations.

The KreATiw project team developed the CR-WSSP approach building on the knowledge and experiences gathered through the publications listed in Table 2. As the list illustrates none of the publications address all of the three approaches and climate resilience.

Table 2 Publications on existing approaches

Publication	Climate resilience	SSP	WSP	W_2RAP
WRC (2011) guideline on W_2RAP				x
WHO (2017) publication on CR-WSP	x		x	
Rickert & van den Berg (2021) publication on CR-WSP	x		x	
WRC (2022) project on CR-WSP/CR-W_2RAP	x		x	x
WHO (2022b) SSP manual		x		
WHO (2022c) WSP field guide			x	
WHO (2023) WSP manual			x	
van den Berg *et al.* (submitted)		x	x	

The CR-WSSP approach developed under the KreATiw project for incorporating climate resilience and integrating the risk management of drinking water and sanitation systems considers seven modules. Each module includes: (i) specific tasks for both systems, (ii) tasks which are supposed to be approached in an integrative manner, and (iii) climate-related tasks which can be conducted by the entire CR-WSSP team or individually by both sub-teams for the drinking water and sanitation services. The climate considerations and a comparison of the modules and tasks included in WSP, SSP and W_2RAP are illustrated in Figure 3.

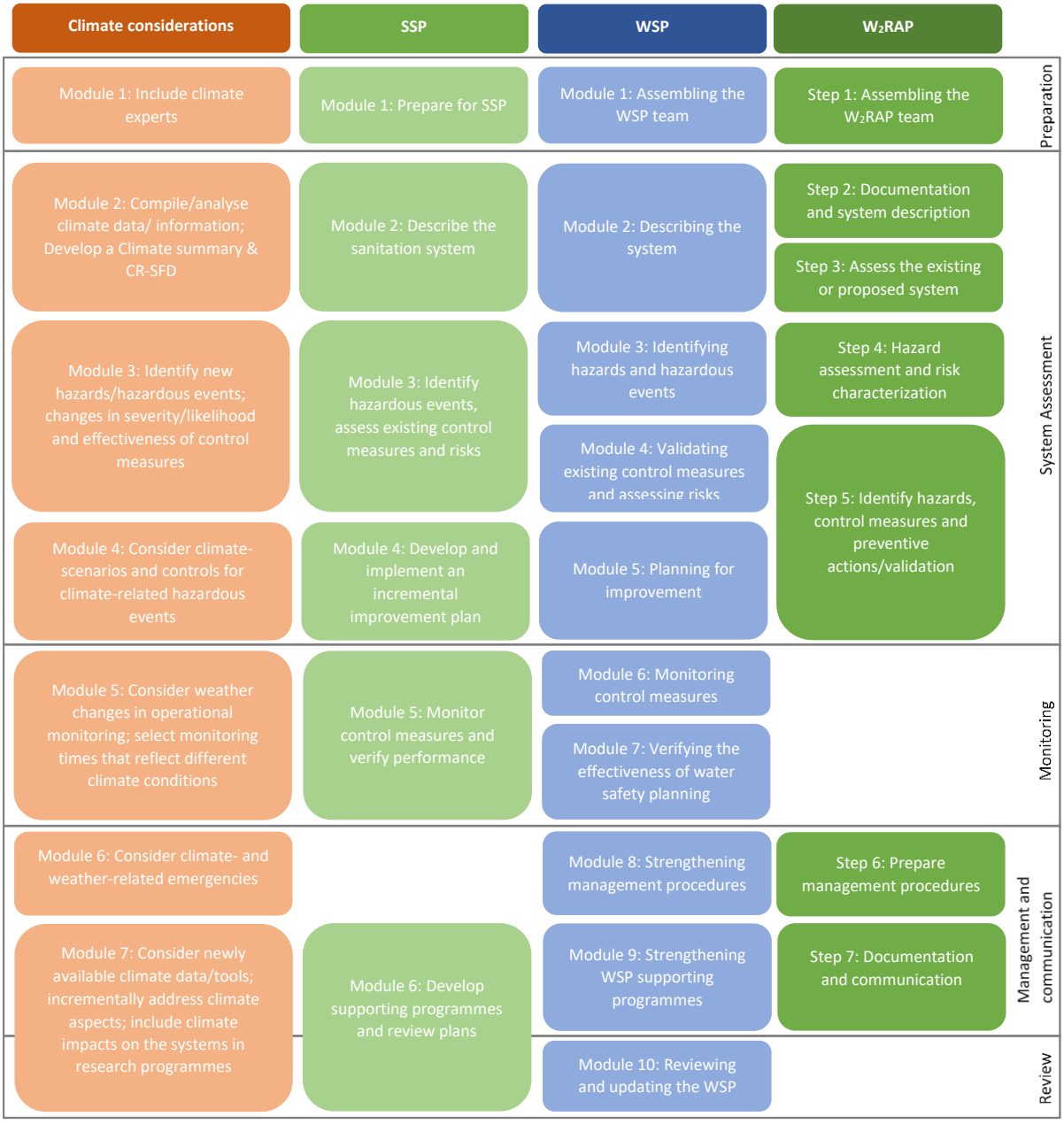

Figure 3 Overview of WSP, SSP and W_2RAP modules and climate considerations included in the CR-WSSP approach

In the following sections, the integrated elements and climate considerations of each of the seven CR-WSSP modules are presented.

Module 1: Establishing the CR-WSSP team

The first module includes the typical WSP and SSP tasks of preparation and establishing the team.

The CR-WSSP team should develop joint objectives such as (van den Berg *et al. submitted*):

- ensuring water and sanitation safety by reducing or eliminating sources of contamination along the services chains;
- improving public health through increased drinking water quality and safety in handling of wastewater and sludge;

- promoting policy and regulatory changes for risk management or the identification of control measures to form the basis of a funding proposal.

Developing a joint schedule at the beginning of the process facilitates regular meetings which should be held in addition to individual meetings of the drinking water and sanitation sub-teams. Having separate meetings is advisable since not all team members have the knowledge to actively contribute to all tasks. Working in a large group can complicate regular meetings due to colliding schedules and possibly large distances between facilities. If data exchange and communication of results is ensured, the team can separately work towards the objectives in between joint meetings.

In addition to the core-team, the following team members with climate expertise may be involved (based on WHO 2017):

- a climatologist specializing in impacts and adaptation planning;
- a hydrologist or hydrometeorologist to advise on the possible climate impacts for the region of interest on water resources/sanitation;
- a public health or water quality/sanitation specialist who can advise on the health impacts of projected climate-related changes;
- an emergency planning or civil protection expert to advise on Disaster Risk Reduction;
- a water or sanitation planner with operational experience in a region where the current climate is similar to that likely to be faced in the future in the CR-WSSP area;
- other specialists, as required, to assist with the risk assessment for any new sources, water management arrangements or wastewater treatment/sanitation techniques that are under consideration.

Module 2: System descriptions and climate summary

In addition to separate system descriptions, the CR-WSSP team should consider the relation of the drinking water and sanitation systems and document interlinkages in a combined map. Examples of such interlinkages can be close proximity of wells and latrines or sewage, septic waste management or open defecation within a catchment.

To access relevant climate data/information, the aforementioned sources can be used. This information should then be collated into a climate summary covering observed and projected climate change and, if available, information on past and expected climate-related hazardous events, their impact on the drinking water and sanitation systems, and associated risk.

Useful information that the CR-WSSP team can include in the climate summary are (WHO 2017):

- detailed information on climate-related hazardous events (such as flooding, increased sea level rise and saltwater intrusion) that could impact water supply and safety;
- projections of changes to key parameters, such as precipitation, temperature, river discharge rates, number of hot days, and frequency of heavy rainfall events (in different climate change scenarios);
- information on the likelihood and magnitude of extreme weather events, such as storms, floods and droughts, in both current climate and future climate scenarios;
- implications for water resources in the region, such as the threats to existing sources and the need to identify new water sources.

In addition, the team can address information on climate variability and develop an SFD which integrates climate considerations. A climate-resilient SFD (CR-SFD) illustrates how different climate-scenarios affect the flow of excreta.

Module 3: Identification of (climate-related) hazardous events and risk assessment

For module 3, the CR-WSSP team should consider which hazardous events affect both systems, or are derived from one, but affect the other. This task is supported by the knowledge of interlinkages the team gained through implementing module 2. Through these considerations, the team can identify the most effective control measures for both systems. To further align the joint work, the team should try to find comparable definitions of severity, likelihood and risk for both drinking water and sanitation risk assessments.

In this module, climate aspects are included through:

- considering additional hazards and hazardous events, such as cross-contamination from flooding of sewer pump stations,
- changes in the severity and likelihood of other hazardous events (for example through increased frequencies and intensity of heavy rainfall),
- impacts on the effectiveness of control measures under different climate scenarios (for example additional treatment required to handle increased pathogens during peak events),
- considering quantity implications of climate change, also considering competing uses and population development,
- increasing raw water monitoring in cases of extreme weather events/changes in climate to inform whether control measures are still suitable for changed conditions and
- validating/conducting performance testing of treatment elements under changed climate conditions and resulting changes in raw water characteristics.

Lists of climate-related hazardous events can be found in the publication by Rickert & van den Berg (2021) on potential hazardous events and their causes and in the publication by WHO (2017) on CR-WSP.

Module 4: Development and implementation of the improvement plan

As part of the improvement plan, the team should identify the control measures that are most effective for both systems. At the same time, the team must consider how changes within the systems affect each other and how ineffective control measures might impact human health.

Implementing identified control measures to manage climate-related risks and improvements that address a wide range of climate scenarios and feed into long-term planning will successfully and sustainably improve the systems' climate resilience. One option of such control measures is the identification of adequate climate-resilient technical solutions.

Module 5: Operational monitoring and verification

Operational monitoring and verification are processes that are largely running independently in both systems. However, it remains important to inform the other system in case monitoring results or ineffective control measures impact it. By way of example, damaged sanitation infrastructure near the abstraction point can indicate an increased likelihood of raw water contamination and must therefore be communicated to the water supplier or their WSP team.

The monitoring processes should include a special focus on new climate-related hazardous events and be specifically designed to cover times of different seasonal climate conditions. If possible, the team should assess monitoring results for peculiarities due to climate conditions and consider monitoring weather changes as part of operational monitoring.

Module 6: Development of management procedures and emergency plans

Similar to module 5, module 6 is mainly conducted separately for the drinking water and sanitation system. Emergency events and developed emergency response actions should be communicated within the CR-WSSP team. Climate- and weather-related emergencies need to be part of these considerations. These can include the planning of redundancies in preparation of extreme weather events.

Module 7: Development and implementation of supporting programmes and review of CR-WSSP

Supporting programmes should include joint trainings for drinking water and sanitation operators to strengthen communication and understanding of both systems and their interlinkages as well as to improve climate risk management. To sustainably improve the condition and operation of the drinking water supply and sanitation system, the team should proactively participate in regular vocational training. Throughout these processes, communication between the sub-teams and the consideration of interdependencies of both systems and their impact on health are key actions. Research programmes and public awareness campaigns are also suitable to address both systems and the consideration of climate impacts.

Throughout the review process, all aspects affecting both systems or where one system impacts another (e.g. sanitation impacts on the drinking water supply system) needs to be communicated, and the use of newly available climate data or data tools should be considered.

In settings where one or both of the approaches (WSP, W_2RAP/SSP) has or have already been developed, the team can aim at incrementally addressing integration and including climate considerations as part of their revision process.

Items of numerical proof

In the following table the most important positions of the numerical proof are presented.

Table 3 Numerical Proof

Position	UBA Expenses (€)	TZW Expenses (€)
Sub-contract to Emanti Management	30.477,91	27.677,31
Travel and HR costs	44.627,86	51.904,92
Sum	75.105,77	79.582,23

Necessity and appropriateness of the project activities

The key objectives in the initial phase of the KreATiw project were to use lessons from South Africa to refine an approach to successfully integrate climate variability and change into existing water supply and sanitation system risk management approaches for a holistic integrated water risk management approach and to pave the way to grow and develop capacity

that enables the roll-out of the approach throughout Southern Africa. All the work carried out has contributed directly to these goals.

The team conducted a thorough situational analysis to acquire a clear picture of the situation of drinking water and sanitation in Southern Africa as well as of already existing risk management approaches. This was essential to create a solid basis for the following project tasks. For example, knowing about existing experiences is important to identify the need for the approach and for existing gaps. Existing experiences also form the basis for the project work. When considering options to transfer the results into national regulation and legislation, it is essential to know about existing regulations.

The webinar hosted by WRC and the workshop held at the WISA conference, provided platforms for the team to ascertain and ensure that the developed approach meets the needs in Southern Africa. These events were also particularly valuable as the resulted in additional stakeholder engagements which led to the identification of project partners for the main phase and possibilities of cooperation.

The development of questionnaires for potential pilot sites and meetings with drinking water and sanitation suppliers were necessary to identify pilot sites for the main phase which differ in size, experience with risk management approaches, experience with climate data, type of treatment and type of the water resources used.

Meetings with universities and international stakeholders aimed at paving the way for capacity building and the broader roll-out in the main phase.

The development of the approach is the basis of the piloting process. In order to monitor and quantify the success of the implementation of the approach at the pilot sites, credible and reliable performance indicators were assembled. This task needed to be completed during the initial phase to facilitate starting the monitoring at the beginning of the project main phase.

Anticipated benefits

As described, the CR-WSSP approach will be tested at the pilot sites whilst using the developed list of indicators based on the analysed success criteria. Diversity was considered in the selection of the pilot sites so that a wide range of sizes, complexities and framework conditions are covered. On the basis of the gained experiences the approach can be refined.

The holistic approach may also gain relevance in Germany in the future, as the aspect of climate resilience in water supply is increasingly discussed. In particular, the implementation of the amended Drinking Water Ordinance, which obliges water supply companies to carry out risk management, can be supported by the experience gained with CR-WSSP.

According to the WHO, integrating climate aspects into risk management approaches such as the WSP and implementing them as such are cost-effective measures for managing climate risks and improving drinking water quality (WHO, IWA 2017; WHO, UNICEF, World Bank 2022). The implementation of risk management approaches can contribute to the health of the connected population which in turn can lead to positive economic impacts in the regions (Gunnarsdóttir *et al.* 2012).

The scientific results, the approval of the project idea expressed in the meetings with stakeholders and the large number of interested pilot sites underline the necessity of the approach. The next step is the development and piloting of the innovative CR-WSSP approach and the training materials needed for its implementation.

Networking and exchange with international partners (e.g. Stellenbosch University, the pilot sites, WHO, UNICEF and GIZ) will be continued and intensified in the main phase through cooperation in piloting, capacity building initiatives and further dissemination of the approach. Through the development and implementation of courses in cooperation with Stellenbosch University, students and practitioners will be trained in CR-WSSP at an early stage, thus creating a basis for climate-resilient risk management to be increasingly implemented beyond the project context in the future. During the main phase, it is planned to publish the project results, especially regarding the experiences from piloting the holistic approach, and to present them at regional and international conferences.

Progress in the field of the project

During the implementation of our project, the WHO published an updated edition of the WSP Manual published in 2009. One major difference between the two editions is the inclusion of climate related issues into the updated WSP process (WHO 2023). Moreover, the SSP manual published in 2015 has been updated to incorporate climate-related risks as well (WHO 2022b). The publishing of these updated versions emphasises the need for climate resilience of water and sanitation services. In addition to the updated manuals, the WHO has published an updated field guide on WSP in rural communities which also emphasises the need to take climate impacts into consideration (WHO 2022c).

Another new development in the field of WSP is an approach to measure climate resilience of water and sanitation systems in low- and middle-income countries by Howard *et al.* (2021). The authors defined 6 areas of interest that are analysed in the process of the evaluation (e.g. water and sanitation service infrastructure) and a scoring system to evaluate the systems' resilience to scenarios related to these domains.

These publications align well with the goals of the KreATiw project indicating the high relevance of research regarding climate-resilient water and sanitation safety planning.

Publications

During the initial phase, the concept and the information collected were presented in a WRC webinar and at a workshop at the 2022 WISA conference. Both events also served to solicit feedback from participants in order to improve the approach and its relevance to the region.

The results produced were submitted as part of a paper titled "Integrated Climate-Resilient Water and Sanitation Safety Planning in Southern Africa: Baseline for Developing a Holistic Approach" in the Journal of Water and Health in April 2023. The training materials developed in the main phase will be disseminated with the help of the above-mentioned regional and global organisations. The team also plans to hold a workshop on the project content at the IWA Water and Development Congress and Exhibition in Kigali, Rwanda, in December 2023, and has submitted a contribution to this effect.

References

Archer E., Engelbrecht F., Hänsler A., Landman W., Tadross M. & Helmschrot, J. 2018. Seasonal prediction and regional climate projections for Southern Africa. In: Climate change and adaptive land management in Southern Africa – assessments, changes, challenges, and solutions. Klaus Hess Publishers, Göttingen, Germany and Windhoek, Namibia, pp. 14-21, doi:10.7809/b-e.00296.

DWS 2022a. Blue Drop Progress Report. https://wisa.org.za/2022/04/01/green-drop-2022-report-release/ (accessed 27 April 2023)

DWS 2022b. Green Drop National Report. https://wisa.org.za/2022/04/01/green-drop-2022-report-release/ (accessed 27 April 2023)

Eastern and Southern Africa Water and Sanitation (ESAWAS) Regulators Association 2022. The Status of the Water Supply and Sanitation Regulatory Landscape across Africa: Southern Africa – Regional Report

Gunnarsdóttir M, Gardarsson S, Elliott M, Sigmundsdottir G, Bartram J. 2012. Benefits of water safety plans: microbiology, compliance, and public health. Environ Sci Technol.; 46(14):7782−9. Available at http://pubs.acs.org/doi/full/10.1021/es300372h (accessed 30 May 2023)

Howard, G., Nijhawan, A., Flint, A. *et al.* The how tough is WASH framework for assessing the climate resilience of water and sanitation. *npj Clean Water* **4**, 39 (2021). https://doi.org/10.1038/s41545-021-00130-5 (accessed 30 May 2023)

Rickert B., van den Berg H. 2021. Climate-resilient water safety plans: compilation of potential hazardous events and their causes. German Environment Agency (UBA), Dutch National Institute for Public Health and the Environment (RIVM). https://www.umweltbundesamt.de/sites/default/files/medien/5620/dokumente/2021_05_14_compilation_of_potential_hazardous_events_and_their_causes_for_climate_resilient_water_safety_plan.pdf (accessed 26 April 2023)

Roeder, L. 2016. SFD Report Kochi. India. https://www.susana.org/_resources/documents/default/3-2303-7-1465206951.pdf (accessed 29 May 2023)

USAID 2021. Water and Development – Indicator Handbook. https://www.globalwaters.org/sites/default/files/usaid_water_indicator_handbook_508_1.pdf (accessed 28 April 2023)

van den Berg, H; Rickert, B.; Lock-Wah-Hoon, J., Jovanovic, D.; Bijelovic, S.; Gligorijevic, S.; Karadzic, V.; Vasic, M.; de Roda Husman, A. *Submitted*. Experiences from integrating water and sanitation safety planning in small systems in rural areas in Serbia. Journal of Water and Health, IWA

WHO 2017. Climate-resilient water safety plans: Managing health risks associated with climate variability and change. World Health Organization, Geneva, Switzerland. https://www.who.int/publications-detail-redirect/9789241512794 (accessed 26 April 2023)

WHO 2022a. UN-Water Global Analysis and Assessment of Sanitation and Drinking water, GLAAS data portal. Retrieved from https://glaas.who.int/glaas/data (accessed 26 April 2023)

WHO 2022b. Sanitation Safety Planning Step-by-step risk management for safely managed sanitation systems, 2nd edn. World Health Organization, Geneva, Switzerland. https://www.who.int/publications/i/item/9789240062887 (accessed 3 January 2023)

WHO 2022c. A field guide to improving small drinking water supplies: water safety planning for rural communities, 2nd edn. World Health Organization Regional Office for Europe, Copenhagen, Denmark. https://www.who.int/europe/publications/i/item/9789289058414 (accessed 26 April 2023)

WHO 2023. Water safety plan manual: step-by-step risk management for drinking water suppliers, 2nd edn. World Health Organization, Geneva, Switzerland. https://www.who.int/publications/i/item/9789240067691 (accessed 26 April 2023)

WHO, IWA 2017.Global status report on water safety plans: A review of proactive risk assessment and risk management practices to ensure the safety of drinking-water. Geneva. World Health Organization. Licence: CC BY-NC-SA 3.0 IGO.

WHO/UNICEF 2022. JMP data retrieved from WASH data portal. https://washdata.org/data/household#!/ (accessed 24 April 2023)

WHO, UNICEF, World Bank 2022. State of the world's drinking water: an urgent call to action to accelerate progress on ensuring safe drinking water for all. Geneva: World Health Organization. Licence: CC BY-NC-SA 3.0 IGO.

WRC 2011. A W2RAP GUIDELINE: To plan and manage towards safe and complying municipal wastewater collection and treatment in South Africa, Development of a wastewater risk abatement plan – a guideline to water services institutions to plan and manage towards safe and compliant wastewater treatment in South Africa, WRC Report No. K8/953/3. https://www.wrc.org.za/wp-content/uploads/mdocs/TT%20489-11.pdf (accessed 26 April 2023)

WRC 2022. Using Climate Data to Help South African Water Services Institutions Improve Water Safety and Wastewater Risk Abatement Planning and Enhance Resiliency to Climate Change at Local and Catchment Level C2019/2020-0124: Deliverable 2: Development of Methodology to Draw Basic Climate Impact Conclusions. WRC Project No. C2019-2020/00124. Available at https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20876_Guidance%20Note%20final%20web.pdf (accessed 17th April 2023)

Annex 1: CR-WSSP approach – detailed module descriptions

	Drinking water	Sanitation	Integration	Climate-resilience
Module 1	Establish a multidisciplinary team including stakeholders who: • have direct control over the drinking water supply system; • have influence over practices that affect water safety and water quantity in the catchment (e.g. regulatory and local authority); • are aware of waterborne infectious diseases (e.g. health agencies); • are affected by actions taken in the water supply to protect water quality (e.g. local community); • represent vulnerable, marginalized or disadvantaged groups; • are interested in drinking water quality (e.g. an NGO working with people affected by the system). Establish priority areas or activities. Appoint a team leader, define and record roles of individuals.	Establish a multidisciplinary team including stakeholders who: • have direct control over some aspects related to sanitation system (e.g. regulatory and local authority); • are aware of waterborne infectious diseases (e.g. health agencies); • represent vulnerable, marginalized or disadvantaged groups; • are interested in final effluent quality (e.g. farmers and downstream users such as industry); • are affected by actions taken in the sanitation system to protect water quality (e.g. local community). Define the system boundary and lead organization, establish priority areas or activities. Appoint a team leader, define and record roles of individuals.	Develop a vision of the integrated approach. Develop a joint schedule. Conduct regular joint team meetings in addition to separate meetings of the drinking water and sanitation sub-teams.	Consider climate experts / expertise in the team.
Module 2	Describe the whole system from the area where the source water originates all the way through to the points of water consumption. Conduct a site visit to gather all important information. Draft a map and a written system description, including information on the performance and vulnerability of the system and all other relevant technical, legal and regulatory information (such as data on drinking water quality).	Describe the whole system, including wastewater and faecal sludge generation, transport, conveyance of wastewater and faecal sludge, treatment, disposal. Characterize the waste fractions (sewered and non-sewered), define exposure groups and exposure routes. Conduct a site visit to gather all important information. Draft a map and a written system description, including information on the performance and vulnerability of the system and all other relevant technical, legal and regulatory information (such as final effluent quality).	Draft description of the relation of the drinking water and the sanitation system / combined map.	Identify and compile/analyse climate data/ information. Draft climate summary, including climate scenarios and variability. Develop a climate resilient Shit Flow Diagram (CR-SFD). Explore points in both systems that are typically affected by extreme events.

	Drinking water	Sanitation	Integration	Climate-resilience
Module 3	Identify microbial, chemical, physical and radiological hazards, quantity, reliability and consumer acceptance as well as hazardous events that could introduce them to the drinking water supply system. Identify existing control measures / barriers to contamination that are already in place. Assess and prioritize the risk to health depending on how often a hazardous event could happen, and how severe its consequences could be. Consider applying sanitary inspection forms for small systems.	Identify microbial, chemical, physical and radiological hazards, quantity, reliability and consumer acceptance, effects on the health of workers, as well as related hazardous events along the sanitation service chain. Refine exposure groups and exposure routes. Identify existing control measures / barriers to contamination that are already in place. Assess and prioritize the risk to health depending on how often a hazardous event could happen, and how severe its consequences could be. Consider applying sanitation inspection forms for small systems.	Consider the effects of events in the sanitation system on the drinking water system and vice versa. Make sure not to subjectively prioritize one system over the other. Draft comparable definitions of severity, likelihood and risk for drinking water and sanitation risk assessment.	Consider new hazards / hazardous events initiated by seasonal factors / climate variability / changes. Consider changes in severity and / or likelihood. Consider the impact of climate variability / changes on the effectiveness of control measures. Consider quantity implications of climate change, also considering competing uses and population development. Increase raw water monitoring in cases of extreme weather events/ changes in climate to inform whether control measures are still suitable for changed conditions. Validate / conduct performance testing of treatment elements under changed climate conditions and resulting changes in raw water characteristics.
Module 4	Develop a detailed improvement plan, describing actions to address important risks and thereby improve the condition and operation of the drinking water supply. This is typically achieved by either adding new control measures or by enhancing existing controls. Incrementally implement the improvements.	Develop a detailed improvement plan, describing actions to address important risks and thereby improve the condition and operation of the sanitation system. This is typically achieved by either adding new control measures or by enhancing existing controls. Incrementally implement the improvements.	Consider for high risks whether action in the drinking water system or in the sanitation system has the bigger impact in reducing the risk. Consider communication and training as key action, highlight interdependencies between both systems.	Improve climate-resilience. Consider improvements suitable for a range of climate-scenarios and the impacts of climate change on long-term plans. Identify additional control measures to manage climate-related risk.

	Drinking water	Sanitation	Integration	Climate-resilience
Module 5	Conduct operational monitoring in the drinking water supply to ensure that control measures work effectively at any given point in time. Conduct verification monitoring to confirm that the WSP as a whole works effectively. Track and assess consumer satisfaction.	Conduct operational monitoring in the sanitation system to ensure that control measures work effectively at any given point in time. Conduct verification monitoring to confirm that the SSP as a whole works effectively.	Be aware of potential effect that in-effective control measures/ operational problems have on the other system and communicate them. Communicate results of verification monitoring in case it includes information on identified parameters that have an impact on the other system, respectively.	Consider monitoring for new hazards that are introduced through climate variability and change. Consider weather changes in operational monitoring/ Select monitoring times to cover times of different climate conditions. Assess data for peculiarities due to climate conditions.
Module 6	Develop standard operating procedures (SOPs). Review and update existing operational and maintenance manual. Develop an emergency response plan.	Develop standard operating procedures (SOPs). Review and update existing operational and maintenance manual. Develop an emergency response plan.	Communicate emergencies including emergency response actions.	Consider climate- and weather-related emergencies when developing management procedures. Plan redundancies for extreme weather events.
Module 7	Identify and implement supporting programmes to communicate health issues with all stakeholders, support water safety and proper operation of control measures. Periodically review and update the WSP outputs: after an incident, emergency or near miss; after major improvements or changes to the system; after an audit or evaluation to incorporate findings and recommendations.	Identify and implement supporting programmes to communicate health issues with all stakeholders, support sanitation safety and proper operation of control measures. Periodically review and update the SSP outputs: after an incident, emergency or near miss; after major improvements or changes to the system; after an audit or evaluation to incorporate findings and recommendations.	Consider training programmes for both drinking water and sanitation operators to strengthen communication and understanding of both systems and their interdependencies. Include supporting programmes such as research programmes and public awareness campaigns that highlighting how both systems affect each other. During review, communicate and consider aspects that might affect the other system.	Include climate risk management in supporting programmes. Consider newly available climate data/tools. Include climate impacts on drinking water and sanitations systems in research programmes.

Annex 2: List of performance indicators

N.°	Category	Metric	Applies to
1	CR-WSP-Team/CR-SSP-Team/CR-WSSP-Team	Did you document the team membership and is the list up to date?	san&dw*
2	CR-WSP-Team/CR-SSP-Team/CR-WSSP-Team	Are all relevant stakeholders with responsibility for the water supply / sanitation represented on the team?	san&dw
3	CR-WSP-Team/CR-SSP-Team/CR-WSSP-Team	Are relevant supporting organizations involved (e.g. health and/or water offices/climate specialists)?	san&dw
4	CR-WSP-Team/CR-SSP-Team/CR-WSSP-Team	Are responsibilities within the team clearly defined and documented?	san&dw
5	CR-WSP-Team/CR-SSP-Team/CR-WSSP-Team	Does the team meet regularly i.e. at least annualy or after an incident (adequate to status of the process)?	san&dw
6	CR-WSP-Team/CR-SSP-Team/CR-WSSP-Team	Are team meetings and outcomes documented?	san&dw
7	System description	Are all water sources used by the community documented in the WSP / CR-WSSP?	dw
8	System description	Are the catchment areas of the drinking water abstractions known?	dw
9	System description	Is the map/system diagram clear and complete and does it reflect current system conditions?	san/dw**
10	System description	Is the map/system diagram up to date?	san/dw
11	System description	Do you conduct regular site visits/inspections from catchment area to tap / sanitation system?	san/dw
12	System description	Have you described all steps of the water supply / sanitation value chain?	san/dw
13	System description	Are household-level water treatment and storage practices understood and documented (where applicable)?	dw
14	System description	Have you identified and documented exposure groups and exposure routes?	san
15	System description	Have you developed a Shit Flow/Excreta Flow Diagram (SFD)?	san
16	Hazard Analysis	Are hazardous events documented for all parts of the water supply/sanitation system?	san/dw
17	Hazard Analysis	Have you considered the type of hazards associated with the identified hazardous events (i.e. microbial, chemical or physical)?	san/dw
18	Hazard Analysis	Is raw water quality/effluent quality analyzed as per local requirements?	san/dw
19	Risk assessment	Have you ranked the hazardous events through a risk assessment?	san/dw
20	Risk assessment	Is the risk assessment based on clearly defined classes of likelihood and severity of the consequences?	san/dw
21	Risk assessment	Are reasons/assumptions leading to the assessment of likelihood and severity of the consequences documented in a comprehensible way?	san/dw
22	Risk assessment	Is the risk assessment complete and covers all process steps (i.e. water and sanitation value chains)?	san/dw
23	Control measures	Have you identified existing control measures?	san/dw
24	Control measures	Have you considered existing control measures in the risk assessment?	san/dw
25	Control measures	Have you conducted a two-step risk-assessment (with/without existing control measures?)	san/dw
26	Control measures	Have you documented existing control measures including responsibilities?	san/dw
27	Control measures	Have you documented evidence that the selected measures are suitable to effectively manage the risks?	san/dw
28	Monitor control measures and verify the effectiveness of the CR-WSSP	Is there an inspection plan documented and is it being carried out as planned?	san/dw

N.°	Category	Metric	Applies to
29	Monitor control measures and verify the effectiveness of the CR-WSSP	Does the plan address what will be done if something is wrong and needs correction?	san/dw
30	Monitor control measures and verify the effectiveness of the CR-WSSP	Is water quality monitored regularly?	san/dw
31	Monitor control measures and verify the effectiveness of the CR-WSSP	Are the parameters being tested adapted to the identified site risks?	san/dw
32	Monitor control measures and verify the effectiveness of the CR-WSSP	Do the results of the water quality testing indicate compliance with drinking water / effluent water quality standards?	san/dw
33	Monitor control measures and verify the effectiveness of the CR-WSSP	Are the results of internal and external water quality testing made available to the CR-WSSP team?	san/dw
34	Develop and implement an incremental improvement plan	Has an improvement plan been documented?	san/dw
35	Develop and implement an incremental improvement plan	Have improvements been identified for all significant risks, including those requiring support and/or funding from outside the community?	san/dw
36	Develop and implement an incremental improvement plan	Does the plan also consider non-infrastructure improvements (e.g. improved monitoring, maintenance or caretaker training)?	san/dw
37	Develop and implement an incremental improvement plan	Does the plan clearly describe what should be done, who should do it, how much it will cost and when it should be done?	san/dw
38	Develop and implement an incremental improvement plan	Are improvements being carried out as planned?	san/dw
39	Document, review and improve all aspects of CR-WSSP implementation	Are standard operating procedures available to the WSSP team members in written documents?	san/dw
40	Document, review and improve all aspects of CR-WSSP implementation	Are there clear written or pictorial instructions to guide important operations or maintenance tasks (e.g. reservoir cleaning, pipe repair, chlorination)?	san/dw
41	Document, review and improve all aspects of CR-WSSP implementation	Are there records of operations and maintenance tasks?	san/dw
42	Document, review and improve all aspects of CR-WSSP implementation	Have you developed and documented emergency response plans and communication protocols in the event of a water quality incident or emergency (e.g. including health office contact information or a plan for issuing a boil water advisory to community members)?	san/dw
43	Document, review and improve all aspects of CR-WSSP implementation	Is the CR-WSSP reviewed and revised regularly (i.e. annually or after an incident as per best practice)?	san/dw
44	Holistic risk management approach	Are you continuously considering aspects of your CR-WSSP (development, operation, verification and review) as part of your day-to-day work?	san&dw
45	Holistic risk management approach	Does the WSP- team have access to the documentation for SSP and vice versa?	san&dw
46	Holistic risk management approach	Is there a common map/system diagram on sanitation and drinking water?	san&dw
47	Holistic risk management approach	Are there regular common meetings & communication between experts/team members for drinking water and sanitation?	san&dw
48	Holistic risk management approach	Are residual risks from sanitation considered as hazardous events for drinking water?	san&dw

N.°	Category	Metric	Applies to
49	Consideration of climate information and resilience	Has relevant climate-related information for the water supply & sanitation system been identified and documented?	san/dw
50	Consideration of climate information and resilience	Have climate-related hazardous events / issues been identified and prioritized, considering the current and future impact of climate variability and change?	san/dw
51	Consideration of climate information and resilience	Have you identified, prioritized and implemented system improvements that manage significant climate-related risks?	san/dw
52	Consideration of climate information and resilience	Have you developed emergency response plan(s) that also cover the relevant climate-related emergencies within the water supply system and sanitation systems (e.g. flooding, drought)?	san/dw
53	Consideration of equity	Have you identified and documented disadvantaged groups within the community / water /sanitation service area?	san/dw
54	Consideration of equity	Have you identified and prioritized hazardous events / issues affecting disadvantaged groups?	san/dw
55	Consideration of equity	Do you analyze monitoring data (e.g. water quality monitoring or monitoring of consumer satisfaction) disaggregated by gender or other social stratifiers (e.g. income)?	san/dw
56	Consideration of equity	Do your emergency response plans and communication / education programs consider the special needs of different groups in the community (e.g. considering different languages, literacy levels and physical abilities)?	san/dw

*san&dw – applies to sanitation and drinking water system, will be answered by the CR-WSSP team

** san/dw – applies to sanitation and drinking water system individually, will be answered by sub-teams