

**THE UNITED REPUBLIC OF TANZANIA**  
**MINISTRY OF WATER**



**GUIDELINES FOR THE PREPARATION OF WATER SAFETY  
PLANS - RESILIENT TO CLIMATE CHANGE  
FOR URBAN WATER SUPPLY UTILITIES**

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Ministry of Water

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## **ABBREVIATIONS**

CBOs	Community Based Organization
CoC	Certificate of Compliance
CR-WSPs	Climate Resilient Water Safety Plan
DfiD	Department for International Development
DHO	District Health Officer
DWE	District Water Engineer
HWTS	Household Water Treatment and Safe Storage
IWA	International Water Association
LGAs	Local Government Authorities
LPHC	Low Probability/ High Impact
MET	
MKUKUTA	Mkakati wa Kukuza Uchumi na Kupunguza Umaskini Tanzania
MoHSW	Ministry of Health and Social Welfare
MoW	Ministry of Water
NAWAPO	National Water Policy
NCDs	Non Communicable Diseases
NGOs	Non Governmental Organizations
R-WSP-TWG	Regional Water Safety Plan Technical Working Group
SOPs	Standard Operation Manual
TBS	Tanzania Bureau of Standard
TMA	Tanzania Meteorological Agency
ToT	Training of Trainers
TWG	Technical Working Group
TWQS	Tanzania Water Quality Specification
UN	United Nation
UNICEF	United Nations Children's Emergency Fund
V&A	Vulnerability and Adaptation



WASH	Water, sanitation and Hygiene
WDC	Water Development Committee
WEDC	Water Engineer Development Centre
W.H.O	World Health Organisation
WSDP	Water Sector Development Programme
WSP	Water Safety Plan

## DEFINITION OF TERMS

Climate:	Climate is average weather and occurs over long time frames (e.g. 30 years)
Climate change:	A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
Climate variability:	Refers to variations in the mean state and other statistics of the climate on all spatial and temporal scales beyond that of individual weather events.
Climate scenario:	A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models.
Control measures:	are activities or processes to prevent or reduce a hazardous event/hazard. The WSP process involves consideration of both existing control measures and new/proposed control measure (or improvements).
Critical limit:	is cutoff point that signifies when a control measure has failed or is working ineffectively and therefore emergency action is required
Hazard:	is a biological, chemical or physical agent that has the potential to cause harm. Hazards are harmful microorganisms (bacteria, parasite, protozoa, and/or virus), or chemicals (fluoride, arsenic, lead, etc) or physical (turbidity,) and/or lack of water that might affect health of the consumer or affect the water supply system.
Hazardous event:	is an event or situation that can introduce a hazard to the water supply system. They are unfavourable condition, through which hazards enter into any stages of the water supply system such as heavy rainfall causing runoff entering the water source or treatment units with animal/human faeces. Collecting and storing water with dirty jerry can and unclean hand introduces pathogenic microorganisms (hazards).
Risk:	is the likelihood that a hazardous event/hazard will occur combined with the severity of the consequences.
Sanitary survey:	is an on-site inspection of water supply to identify actual and potential sources of hazards such as physical structure, operation of the system, and external environmental factors.



- Validation:** refers to reviewing evidence to determine whether or not the existing control measures can effectively control the hazardous event/hazard. This must be done prior to risk assessment so that the risk assessment considers how well controlled the hazardous event/hazard is currently.
- Verification:** Monitoring to confirm the effectiveness of the WSP as a whole and involving three elements: 1) compliance monitoring 2) consumer satisfaction survey; and 3) internal/external WSP auditing.
- Water safety plan:** A comprehensive risk assessment and risk management approach that encompasses all steps in the water supply, from catchment to consumer
- Weather:** is what is happening in the atmosphere at any given time is considered “weather” (including e.g. wind speed and direction, precipitation, barometric pressure, temperature, and relative humidity)

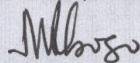
## FOREWORD

The Government of Tanzania instituted water sector reforms in 2002 as articulated in the National Water Policy (2002). The overall objective of the reforms/policy, as being coordinated by the Water Sector Development Programme (WSDP), is to strengthen sector institutions for integrated water resources management and improve access to clean and safe water supply and sanitation services. There are a number of instruments which have been established since then in order to facilitate efficient and effective implementation of the reforms which include; the National Water Sector Development Strategy (2006 – 2015), Water Resources Management Act No. 11 of 2009, Water Supply and Sanitation Act No. 12 of 2009, Vision 2025; 5 years development plan; and MKUKUTA II.

Despite major efforts by the Government to ensure communities both in urban and rural areas have access to clean and safe water, the country is experiencing a number of challenges that include; pollution and degradation of water sources; inadequate water treatment for domestic use; low awareness on household water treatment and safe storage (HWTS), and weak water supply and distribution infrastructure. Similarly the impacts of climate change can manifest through a number of ways including increased average temperatures, higher freshwater temperatures, sea-level rise, more extreme precipitation, floods and increased drought in different areas causing tremendous pressure on the water supply systems and ecosystems at large.

Water Safety Plans (WSP) will enable the operators and managers of the Urban Water Supply Authorities to know the system thoroughly, identify where and how problems could arise, put multiple barriers and management systems in place to stop the problems before they happen and making all parts of the system work properly so as to ensure safety of water intended for human consumption and other domestic uses in adequate quantity. The WSP will play as a vital tools for comprehensive risk assessment and risk management approach that will encompass all steps in the water supply system from catchment to point of consumption.

It is my expectation that these Guidelines will create uniformity in approaches, for the development and implementation of Water Safety Plans and restore the state of the art for the availability of clean and safe water at all levels.



Eng. Mbogo Fதாகamba  
**Permanent Secretary**



## ACKNOWLEDGEMENT

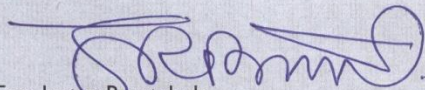
These Guidelines for the Preparation of Water Safety Plans for Urban Water Supply Utilities are a result of combined efforts of the Ministry of Water, Ministry of Health and Social Welfare, Vice President's Office, World Health Organization (W.H.O) and other stakeholders.

First and foremost, the Ministry of Water acknowledges with great appreciation the valuable support from DFID and WHO that provided the financial and technical support respectively for the preparation of these Guidelines.

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**Director Urban Water Supply**

# **CHAPTER ONE: INTRODUCTION**

## **I.1. BACKGROUND**

Access to safe drinking water is a basic human right. The National Water Policy (NAWAPO), 2002, calls for increased populations who access clean and safe water supply, and improved hygiene and sanitation aimed to reduce the burden of waterborne and related diseases thereby improving health and prosperity of the country. The water quality standards of 2008 also require drinking water service providers to maintain the required microbiological and physicochemical quality characteristics (TWQS, 2008).

Diseases attributable to consumption of unsafe water and poor sanitation and hygiene such as diarrhea, intestinal parasitic and protozoan infections remain among the top ten leading causes of morbidity and mortality in the country. It is reported to account for 7% of deaths in children below the age of five years (UNICEF, 2013). It is estimated that most of these episodes are believed to be caused mainly by consumption of unsafe water (Hunter et al., 2013; Getua et al., 2014). Furthermore, routine data from hospital visits shows that more than 80 % of hospital attendances are caused by preventable diseases (MoHSW, 2010), diarrheal being among them. Higher prevalence of diarrheal diseases is observed despite increased access to improved water supply in urban areas which is estimated to be 86 % (MoW, 2014). This is partly caused by poor water supply infrastructure systems such as broken pipelines allowing contaminants to enter water supply system, poor water storage and hygiene practices at the household level leading to post contamination, unreliable power supply leading to intermittent water supply that forces people to revert to and rely on unsafe water sources. Moreover, poor management of solid and liquid wastes together with open defecation practices exacerbates risks to water safety and public health hazards.

Climate change and variability has also shown to affect both water quantity and quality. Excess rains cause floods which may destroy water sources, water treatment plants and water supply infrastructure. Floods carries with it contaminants which are carried down to water sources causing gross contamination. On the other hand, climate change causes shortage of rainfall which results in lowering of ground water table and water bodies thereby affecting quantity of water supplied. In addition, climate change is associated with a rise in sea level causing salt intrusion into fresh water bodies.

It is in this context that the Ministry of Water has prepared these Guidelines so as to guide urban water supply authorities in the supply of clean and safe water to populations with consideration of adverse impacts of climate.

## **I.2. CLIMATE CHANGE AND WATER QUALITY**

Climate Change would possibly result to prolonged rainfall and thereby causing flood or otherwise lack of rainfall and higher temperatures leading to serious drought. The major water quality related issues that may impact heavily on community health include:



1. Increased concentration of pollutants when conditions are drier. This is of particular concern for groundwater sources that are already of low quality in areas where concentrations of arsenic, iron, manganese, and fluorides are often problems.
2. Increased storm runoff can increase loading of pathogens, nutrients, and suspended sediment.
3. Sea level rise that increases the salinity of coastal aquifers, in particular where groundwater recharge is also expected to decrease.
4. Algal blooms and increased risks from cyanotoxins and natural organic matter in water sources as a result of higher water temperature, requiring additional or new treatment of drinking-water.

Table 1: Potential Health Impacts of Climate Change and Variability

Exposures affected by climate change	Potential health risks	Health impacts
Increased average temperatures	Accelerated microbial growth, survival, persistence, transmission, virulence of water-borne pathogens;	Increased risks of food- and water-borne diseases
Increasing drought	<p>Lower water availability for washing, cooking and hygiene, increasing exposure to water-borne contamination.</p> <p>Decreased food security and increased risk of malnutrition, interacting with water-borne diseases.</p> <p>Lower food production in tropics; lower access to food due to reduced supply and higher prices; combined effects of undernutrition and infectious diseases; chronic effects of stunting and wasting in children</p>	<p>Increased burden of food- and water-borne disease.</p> <p>Increased risk of under-nutrition resulting from diminished food production in poor regions</p>
More extreme precipitation events	<p>Lack of water for hygiene; flood damage to water and sanitation infrastructure, and contamination of water sources through overflow</p> <p>Very high rainfall can reduce mosquito and other vector populations (e.g. schistosomiasis) by flushing larvae from their habitat in pooled water</p>	<p>Increased risks of food- and water-borne diseases</p> <p>Decreased risk of vector-borne diseases</p>
higher freshwater temperatures (with increased concentration of nutrients such as phosphorus and other	<p>shifting geographic and seasonal distributions of e.g. vibrio cholerae, schistosomia</p> <p>Increased formation of cyanobacterial blooms in freshwater</p>	<p>Increased risks of food- and water-borne diseases such as cholera and schistosomiasis, respectively</p> <p>Liver damage, tumor</p>



Exposures affected by climate change	Potential health risks	Health impacts
factors)		promoter, neurotoxicity (longer-term effects depending on toxin exposed to)
Sea-level rise	Coastal areas experiencing sea level rise may become uninhabitable and influence and influence population displacement or force currently secure water sources out of use because of saline intrusion.  Sea level rise that increases the salinity of coastal aquifers, in particular where groundwater recharge is also expected to decrease.	Increased risk of water-borne diseases, health impacts of high salt consumption on NCDs
More frequent and extreme heat events	Outdoor and unprotected workers obliged to work in physiologically unsafe conditions, or to lose income or livelihood opportunities	Consequences for health of lost work capacity and reduced labour productivity in vulnerable populations

### **I.3. OBJECTIVES OF THESE GUIDELINES**

These Guidelines are designed to provide guidance to urban water supply authorities on the preparation of Climate Resilient Water Safety Plans (CR – WSP). Specifically, the Guidelines will aim to:

1. Provide guidance to urban water supply authorities in the steps involved in preparation of WSP
2. Provide guidance on how urban water supply authorities should integrate climate risks and issues into WSP
3. Provide guidance to urban water supply authorities in the implementation of CR – WSP
4. Provide quick reference for authorities, academicians and all stakeholders in issues related to CR - WSP

### **I.4. RATIONALE FOR THESE GUIDELINES**

Although it is reported that access to improved sources of drinking water and sanitation increases every year in Tanzania, diarrhea remains among the top ten leading causes of under-five child deaths in Tanzania. Diarrhea accounts for 7% of deaths in children below the age of five years (UNICEF, 2013). Despite high morbidity and mortality, it is believed that about 94 % of diarrheal is preventable (WHO, 2007). It is estimated that most of these episodes are believed to be caused mainly by consumption of unsafe water (Hunter et al., 2013; Getua et al., 2014). Furthermore, routine data from hospital visits shows that more than 80 % of hospital attendances are caused by preventable diseases, diarrheal being among them. This burden of diseases is attributable to unavailability of safe drinking water at the point of consumption. Moreover, water pollution at the sources is high due to anthropogenic activities and other

natural causes considering the facts that most local governments have no water treatment facilities, and water laboratories for quality monitoring.

It is also a fact that in recent years, many parts of the country's water supply infrastructure has been affected by effects of climate variability such as flash and river flooding due to increased rainfall that posed damage to water supply sources and infrastructures. This has been associated with gross contamination of drinking water which results in diarrheal disease outbreaks. There are also communities especially in central parts of the country and some areas of north eastern highlands suffer from the effects of prolonged droughts due to shortage of rainfall, evapo-transpiration, which result in lowering of ground water table and water bodies, water shortage and drying of shallow water sources and consequently people are forced to depend on unsafe water provided by water vendors.

In the face of such and other anticipated climate change impacts, there is a need to improve the climate resilience of water supply services to cater for the whole range of climate change risk, including extreme weather events, increasing resource stresses and ensuing water quality and quantity issues. The Water Safety Plan, which is a pro-active and comprehensive risk management approach to ensure the safety and security of drinking-water supplies, provides a valuable framework to address these issues.

The WSP Manual (WHO 2009) notes: "there can be a tendency for the identification of hazards to be limited to thinking about those direct inputs to the water supply system impacting microbial and chemical parameters, as these are important in terms of compliance with water quality standards. However, the approach to ensure safe water must go much wider, with consideration of aspects such as potential for flood damage, sufficiency of source water and alternative supplies, availability and reliability of power supplies, the quality of treatment chemicals and materials, training programmes, the availability of trained staff, service reservoir cleaning, knowledge of the distribution system, security, emergency procedures, reliability of communication systems and availability of laboratory facilities all requiring risk assessment".

In addressing the above mentioned challenges in the country it is important to have a sustainable improvement of water supply system which can be achieved through implementation of the climate resilient water safety plans.

## **I.5. SCOPE**

These Guidelines are intended to be used by Urban Water Supply Authorities for the development and implementation of Climate Resilient Water Safety Plans (CR – WSP). Ministry of Water; MoHSW; Water Basin Offices and other stakeholders will make decisions during planning and budgeting so as to support water supply authorities in planning for water safety and risk assessment interventions to support water utilities in implementation of Water safety plans. Regional Secretariats and LGAs will work collaboratively in support services, monitoring and evaluation of the activities of water supply authorities. Regional Secretariats and LGAs will ensure that populations are supplied with clean and safe water for consumption. Training institutions, academicians and other stakeholder's will also benefit from these Guidelines as a reference materials when addressing issues of Water Safety Plans.

The Guidelines highlight on the major steps involved in Water Safety Plans as well as the respective implementation procedures. Similarly, the Guidelines provide tools for implementation of different steps of the Water Safety Plans.

## **CHAPTER TWO: UNDERSTANDING CLIMATE RESILIENT WATER SAFETY PLANS**

### **2.1. DEFINITION OF WATER SAFETY PLANS**

The World Health Organization (WHO) defines water safety plans as a comprehensive risk assessment and risk management approach to identify and address priority issues that affect service delivery.

Water safety plans were first introduced in the WHO Guidelines for Drinking Water Quality, 3rd edition (WHO, 2004) and continued in the fourth edition (WHO, 2011). It is an effective strategy to ensure water safety from catchment to the point-of-consumption. Climate-resilient WSPs (CR-WSPs) ensure that priority risks to water quality and quantity associated with climate variability and changes are identified and addressed through the WSP process. WSPs will identify appropriate adaptation options to address current and anticipated adverse effects on drinking water supply systems so as for them to become resilient to climate change.

The conventional practices of water quality management through end pipe testing are limited to occasional testing of samples of drinking water mainly from consumer taps or in response to incidence of outbreaks. Such practices are reactive and test results are available after too many people affected and late for preventive action. In addition it doesn't include the whole water supply system namely continuity, quantity, users concerns and sustainability. Therefore, it is high time for urban utilities to adapt the WSPs which are aimed at improving the water supply system through risk assessment and risk based management approach.

### **2.1. BASIC CONCEPTS OF THE WSP FOR URBAN UTILITIES**

Water safety plan (WSP) is the most effective means of consistently ensuring the safety of a drinking-water supply through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer (WHO, 2009).

The approach enables the operators and managers of water utilities to know the system thoroughly, identify where and how problems could arise, put multiple barriers and management systems in place to stop the problems before they happen and making all parts of the system work properly so as to ensure the safety and acceptability of a drinking water supply intended for human consumption and other domestic uses as summarized in the following WHO safe water chain frameworks.



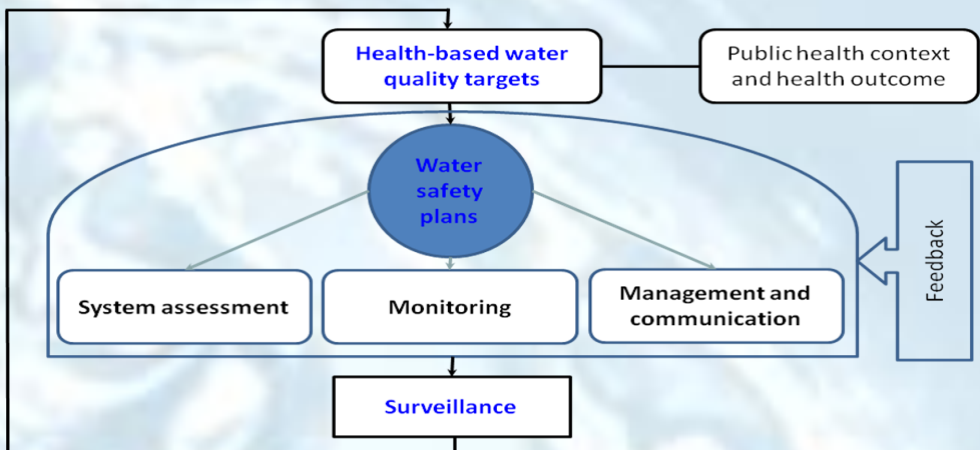


Figure 1: Safe Water chain framework adapted from WHO Drinking Water Quality Guidelines 4th edition, 2011

The safe water chain framework has five components important to ensure safety of the drinking water. Three out of the five key components will be planned and implemented by the water utilities and the remaining two components (Health-based water quality targets and surveillance) are responsibilities of the surveillance/regulatory agency.

## 2.2. BENEFITS OF WATER SAFETY PLAN

Water safety plan as a proactive tool aims to ensure safety of water from source to point of consumption and ultimately provides adequate quantity of safe drinking water to the population. The approach entails to determine whether the safety of the drinking water is maintained from catchment to point of consumption; documentation of the system assessments; monitoring and further preparation of the management plans to address actions to be taken during regular operation and when incident conditions might happen. In addition, added value of the water safety plan is stated as follows;

- i. Protection of public health through improved water quality and thereby improved productivity
- ii. Improves compliance with international and national drinking water quality standards
- iii. Improves planning, risk identification and management as well as operation and maintenance capacity of the water supply operators
- iv. Create clear understanding about water supply systems, asset management, and to predict future investment needs
- v. Brings together wider range of expertise from different sectors and improves relationship and partnership between stakeholders
- vi. Improves organizational efficiency and performance of utilities



### 2.3. INTEGRATION OF CLIMATE CHANGE IN WSP

Planning for safe water supply in sufficient quantity in the long-term is set in the context of growing external uncertainties arising from changes in the climate and environment. The WSP offers a framework to manage these risks by considering the implications of climate variability and change risks at various steps points in the WSP process. This section sets out the key considerations aligned with the WSP approach

1. The WHO Guidelines for Drinking-water Quality (WHO 2011) recommends WSPs as a comprehensive risk management approach to most effectively ensure drinking-water safety. WSPs are at the heart of the Framework for Safe Drinking-water.
2. The WHO/IWA WSP Manual (WHO 2009) provides practical guidance to support WSP development and implementation for water supplies managed by a water utility or a similar entity.
3. The WSP steps addressed in this document are those that consider climate change to ensure sufficient management of climate-related risks through the WSP process. These are as displayed in the figure below

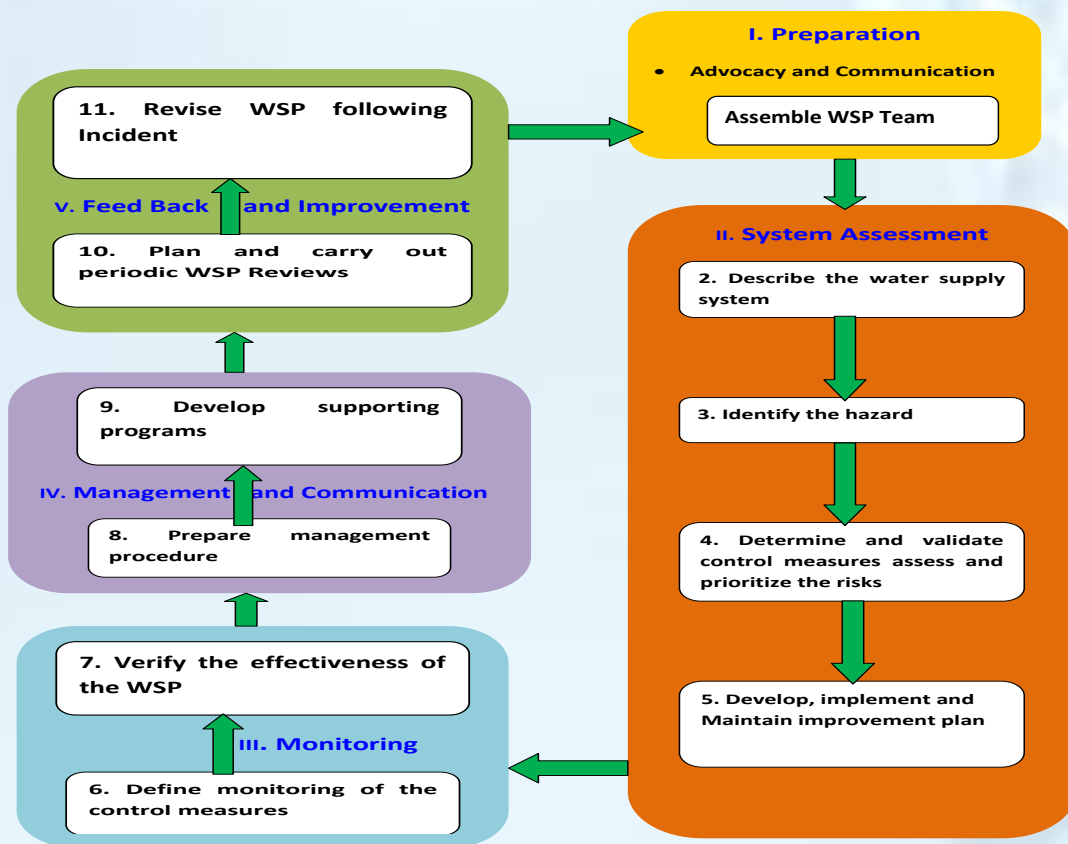


Figure 2: Steps for Water Safety Planning

## **CHAPTE THREE      DEVELOPMENT AND IMPLEMENTATION OF CLIMATE RESILIENT WATER SAFETY PLANS**

Development of a WSP aims at preventing contamination and maintaining yield of the water sources, treating of water to eliminate or remove contaminants, and prevention of recontamination of water in the reservoirs and distribution systems and use at household levels. To achieve intended results, the WSP development process for urban water utilities passes through five interdependent major steps. Under each step there are different activities to be undertaken sequentially by involvement of suppliers, regulators and other internal and external stakeholders.

The major five steps include:

1. Preparation for WSP development
2. System Assessment
3. Monitoring
4. Management and communication, and
5. Feedback and improvement.

### **3.1. STEP ONE - PREPARATION FOR WSP**

Preparation of WSP involves formulation of the water safety team to facilitate its development and implementation. However, before embarking on assembling the intended team, different stakeholders should be made aware of the whole concept of WSP. The advocacy should focus on mobilizing key stakeholders ranging from policy makers, regulators, meteorological agency, local governments as well as various water users as prioritization may require.

Since most of the risks posed by climate variability and change in water resources will be similar in the same ecological or climatic zone, it is recommended to ensure that a vulnerability and adaptation assessment in relation to water is conducted at a higher level (e.g. regional, ecological or climatic). A group of experts will be selected at the selected level to conduct the vulnerability and adaptation assessment (V&A) and will include hydrologists, climatologists that will be in charge of perform climate and hydrology modelling and can also support with the development of risk maps.

Furthermore, a health vulnerability and adaptation assessment will also be conducted ideally at the same regional, climatic, ecological scale. The combination of results of both V&As (i.e. water and health) will provide the evidence required to inform the implementation of CR-WSPs at utility level.

For effective implementation of the WSP in the respective area, the team to be established should have qualified and dedicated members with clear knowledge of the water supply system (water source, treatment processes, storage, distribution systems & household storage) and catchment characteristics in terms of drainage pattern and quality dynamics. It is in this context that, the WSP team should be drawn from within and external entity such as water utilities, basin water board/catchment offices, water quality organizations, as well as other stakeholders such as water users as prioritization may require.

Since the team formulated will be responsible for developing, implementing, maintaining as well as upgrading the WSP to be developed, it is recommended that the team members should have adequate

knowledge and experience regarding the understanding of water abstraction, treatment processes and distribution and the hazards that can affect water quality and safety through the supply system from the catchment to the point of consumption. It is also advised that, the team should include some senior management staff so that to have management commitment in the whole process of formulation and implementation of WSPs. The WSP team will be responsible for the inclusion of the results of the V&A to the different steps involved in the implementation of WSPs.

In order to have an effective WSP team, water utilities responsible for urban water supply should ensure the following:

### 3.1.1. Engage the community

Community engagement involves:

- i. Identification of key stakeholders and creation of awareness on WSP concept and benefits among the community.
- ii. Consultations meetings to the community, community leaders, community workers, LGAs, religious organizations and other nongovernmental organizations to understand about WSP approach.

Before arranging the stakeholder's consultation meeting, the water utility should work on the following:

- i. Identify key stakeholders and justify their importance (reasons why they should be consulted);
- ii. Review reports and organize evidences on the effects of temperature, extreme rainfall, floods and drought on the community water supplies and associated health problems;
- iii. Make preparation where and when to conduct the consultation meetings (arrange venue, schedule and necessary logistics);
- iv. Convene the consultative meeting.

### 3.1.2. Conducting the stakeholders meeting

During the stakeholders meeting, the Urban Water Supply Utility members should:

- i. Define and explain to the stakeholders about the CR – WSPs and also create an in depth and clear understanding that WSPs is not a new program but is a tool designed to ensure water safety from catchment to point of consumption and to sustain services.
- ii. Explain that WSPs approach is a means to achieve the national water quality standard specification, recommended water quantity, resilience of the supply system to climate change and therefore facilitate implementation of the government policy.
- iii. Reveal that WSPs approach safeguards health of the community by ensuring water safety through removal of contamination risks and risk to the sustainability of the water supply system.
- iv. Elaborate that WSPs is a means to show practical case that communities have capacity and resources to solve water safety problem, sustainability of the supply and that it opens opportunities for formal and informal community leaders to ignite and facilitate participation of the communities in the activities that contribute to and sustain their social and economic developments.

- v. Show that WSPs creates platform for improving partnership, cooperation and support network between WASH stakeholders and between neighboring communities.

### 3.1.3. Assemble a Water Safety Plan Team

A Water Safety Plan Team should comprise of community members; formal, informal and influential community leaders; and professionals with different expertise. When utilities are too big and serve large populations it may be decided to conduct a specific V&A at urban utility level. In this case, experts in climatology, hydrology and hydrogeology should be included in the WSP team, who will be responsible for conducting vulnerability and adaptation assessment (V&A) as part of the system assessment. The V&A conducted for water will provide the information required to fully understand the health risks posed by climate change as mediated by both water quantity and quality. The V&A assessment provides information required to fully understand the health risks posed by climate change as mediated by both water quality and quantity and of policies and programs that could increase resilience, taking into account the multiple determinants of climate—sensitive health outcomes; Hydrology modeling and climate modeling; Hydrology mapping and Regional forecasts of extreme weather events (e.g. droughts and floods).

Other members of the WSP Team should have expertise in

- i. Community water supply schemes operation, maintenance and extension;
- ii. Water quality/ environment/ health - standard specification; sampling; testing; analysis and sanitary surveys;
- iii. Agricultural development and natural resource management;
- iv. Community development and gender issues;
- v. Water, Sanitation and Hygiene at household and institutional level (schools, health facilities and public places);
- vi. Others should include: community government leaders; influential persons; religious leaders; NGOs; and CBOs



Table 2: Expected duties of the WSP team members

SN	Professional category	Expected duties of the team members	Remarks
1	Utility technical manager	Decision making and provision of resources (human, financial, and logistics)	Team leader
2	Water engineer/surveyor (operation and maintenance)	Description and characterization of the water supply system layout mapping and technical assessment to water supply system assets from intake to distribution point such as breakage, type and size of materials, age, leakage and wastage rate, catchment delineation/determination, specification of materials for operation and maintenance, identify hazards and risk levels, priority control measures and corrective actions with timeframe and responsible body to implement the corrective action	Utility staff/team member
3	Sociologist	Description of catchment population/users dynamics including density, number, growth, community concerns related to services of the utility, level of participation, service inclusiveness (urban poor), system in place for communication and customer awareness to notify water safety/quality changes, on utility responsiveness and accountability), billing system, level of expansion of informal settlement, water demand, cost-benefit and vulnerability analysis to inform future water demand, and utility's financial sustainability, and users satisfaction surveys, etc. Take part in the identification and characterization of the hazards and risk levels from customers' (users) perspectives, priority control measures and corrective actions and work on the consolidation whole WSP living document.	Utility staff
4	Water/geo chemist	Determine baseline level of the physicochemical and microbiological quality status of the water supply system from source to point of consumption, water characteristics, monitor critical quality parameter during implementation,	Utility staff
5	Environmental health	Characterizing of the health status of the catchment population including prevalence of diarrhea among under-five children, problem of sanitation and hygiene services, identification of point and diffused sources of contamination (environmental and behavioral contamination risk assessment from catchment to point of use including HH water treatment and storage practices, use of alternate sources, perception about safety/quality of water collected from different sources, etc. identify hazards, risk levels, priority control measures, corrective actions with time frame and responsible body to implement the corrective action.	Health staff
6	Lab technicians	Being parts of the regulatory/surveillance agency jointly work with water chemist of the utility on the establishment of the water quality baseline using the same method and technique, and periodically conduct quality assessment and verify or assure whether or not the supply system meet health based target indicators.	Health staff
7	Environmental officers	Characterize sources and types of pollution in the catchment of the water source due to various socio-economic activities (agriculture, industry, etc) and analyze potential hazards and risk levels, identify priority control measures, corrective actions with time frame and responsible body to implement the corrective action.	Forest or environment or agriculture staff
8	Meteorologist/Hydrologist/ Climatology (at national/regional Levels,	Conducting vulnerability and adaptation assessment (V&A) as part of the system assessment. Two V&A assessments (one for water and one for health) will be conducted at regional, climatic, or ecological zone level.	TMA and water resource staff



SN	Professional category	Expected duties of the team members	Remarks
	where MET stations exist, and also provide weather and climate information for WSP teams in the same climatic zone),	The V&A assessment provides information on current and future vulnerability to the health risks of climate change (with a special focus on water-borne diseases) and of policies and programs that could increase resilience, taking into account the multiple determinants of climate—sensitive health outcomes. The V&A conducted for water will provide the information required to fully understand the health risks posed by climate change as mediated by both water quantity and quality. Hydrology modeling and climate modeling; Hydrology mapping; Regional forecasts of extreme weather events (e.g. droughts and floods).	

#### 3.1.4. Organize Capacity Building Training Program for WSPs Team

There should be a TWG to build technical knowledge and skills to the new WSP Team on the steps of development and implementation of WSPs. The TWG comprising of a DWE, DHO and a facilitator for CR – WSP should make necessary preparation for the training such as:

- i. Identify venue for theoretical and field exercise, and logistics.
- ii. Inform the local administration (government and local leaders) that practical field exercise is conducted in selected village.
- iii. To make field work easier, involve responsible officer from the district water or health office.

Training process should primarily be aimed at creating in-depth understanding on:

- i. The national WASH and environment policies, strategies, national water quality standard specifications, and forming and leading team work.
- ii. Climate change/weather variability and its effects on drinking water supplies.
- iii. Concepts, principles and tasks of the climate resilient water safety plan.
- iv. How to describe water supply systems, identify hazards, hazard events and to characterize risks and existing control measures.
- v. How to develop and implement an incremental improvement plan,
- vi. How to monitor control measures, and verify effectiveness of the water safety plan.
- vii. How to document, review and improve all aspects of water safety plan implementation.

### 3.2. STEP TWO – SYSTEM DESCRIPTION

The main objective of the system description is to have a clear understanding and insight on the physical and operational component of the water supply. That is to say, understanding how the water supply system is designed and functioning from catchment to point of use. It is important to draw the layout map of water supply system that show location and type of the source (s), intake, treatment plant, reservoirs, distribution systems with primary, secondary and tertiary pipe networks, pump stations, valve boxes, public stand posts or household connections. Similarly, the assessment should cover each component of the supply systems.

#### 3.2.1. Description of the Water source or catchment area

The source of water supply systems could be surface water, dam (reservoir), deep borehole, gravity springs or composition of the two or three sources.

- i. Describe location and type of the water source (river, dam, and/or gravity fed spring) and catchment areas /watershed and if the source is ground water, depth of the well, flow rate, depth of casing with schematic diagrams /layout map
- ii. Describe the impacts of climate variability and change (i.e. increased average temperature, increased drought, more extreme precipitation events, higher freshwater temperatures, and sea-level rise) on the source water quality and quantity such as reduced flow rate due to decreased precipitation and evaporation during hot dry seasons, and siltation/sedimentation due to runoff

during rainy season. In order to have detailed insights of the likely impacts, the WSPs team should make use of information gathered in the V&A report conducted at regional, climatic or ecological zone level.

- iii. Nature of the land and its use such as economic activities in the catchment including agriculture, animal husbandry/raring, mining, informal settlement, waste disposal, etc
- iv. Different types of existing water uses and planned activities such as irrigation schemes, hydroelectric development, etc in the water source catchment areas that might introduce chemical hazards such as use of agricultural chemicals, reduction in water source recharge (quantity). On the other hand, an ongoing soil and water conservation activities in the water shed/catchment areas contributes to increasing water source recharge and consequently increase water quantity. Thus, WSPs team will cross check and advocate with natural resource management and agriculture sector for necessary action
- v. Describe changes of the water source discharge rate (yield) during design phase versus current rate and reliability/adequacy of the source taking in to consideration population growth rate (water demand)
- vi. Water source quality and characterization of types and loads of pollution/contaminants due to different type of the socio-economic development activities in the catchment areas,
- vii. Describe kind of source contaminants (wastes from different sources in the catchment areas) including organic, inorganic, and/or chemical wastes
- viii. Existing physical, microbiological and chemical qualities of the water and how quality is seasonally affected due to extreme weather events
- ix. Existing affirmative action such as soil and water conservation interventions
- x. Condition of the wellhead works, possible intrusion of surface water such lake, river or runoff, and any physical condition that affect water quality

### 3.2.2. Description of the Treatment processes:

The treatment system depends on the type and extent of source contamination. The conventional water treatment system commonly used for surface water includes sedimentation, coagulation/flocculation, filtration, and disinfection before distribution. Therefore,

- i. Description of type and number of treatment units with schematic diagram (layout map),
- ii. Details of the treatment plant including how it is operates and contamination removal capacity of each treatment unit, age and current operational status of the treatment plant compared to its initial design
- iii. Details of each treatment processes and type of contaminants the treatment works are designed to remove
- iv. Details how treatments processes are controlled and standards how to decide the treatment processes are properly functioning

- v. Kind of disinfectant used, disinfection contact time and concentration of the disinfection residuals
- vi. Kinds of operational controls to verify efficiency of overall treatment works
- vii. Hazards identified during assessment of catchment (source) that cannot be removed by existing treatment processes
- viii. Effects of climate variability and change (i.e. increased average temperature, increased drought, more extreme precipitation events, higher freshwater temperatures, and sea-level rise) on the water treatment processes such as algal blooming due to high temperature, and burden on the water treatment works as a result of siltation and sedimentation due to runoff entrance and future susceptibility of the treatment plant to extreme weather events.
- ix. Frequency of treatment process interruption and reasons such as power failure, raw water characteristic, and problems related treatment work, etc.
- x. Status of the Technical knowledge and skills of the operation and maintenance workers (operators).Availability of the standard operating procedures (working manuals) and equipment, etc

### 3.2.3. Description of the Storage/service reservoirs:

There are conditions where treatment plant is installed far away from the raw water intake (source of water) and water transported to the treatment plant either by gravity or pumping, and treated water is pumped to main service reservoirs or supply reservoirs located at high altitude and then water is conveyed to though distribution system to the users by gravity systems. Depending on the settlement and number of users, water demand, a number of reservoirs with variable capacity are constructed.

Therefore,

- i. Describe number, capacity (volume), location (site), service age, design and structure of the reservoirs, materials used, and their position of inlet and outlet valves, overflows, manhole cover, shape of top cover slab, vent pipe, etc
- ii. Presence of protection from human and animal access such as cattle, birds, rodents, etc
- iii. Type and size of pipe materials used to convey water from treatment plant to storage/service reservoirs (such as GS, PVC, DCI, etc)
- iv. Range of pressure and retention time
- v. Condition of network such as frequency of bursts of raising mains, and growth of microorganisms in the distribution system such as iron bacteria, corrosion, etc
- vi. Check for possible entrance of contaminated water through the basement /wall / top of the reservoirs, or during no pressure in a network (check for any structural defects)



- vii. Check for possible entrance of contaminants during repair of the distribution networks (during pipe maintenance, reservoir cleaning, etc)
- viii. Check for back flow of contaminated water from consumer's premises during period of supply interruption (back siphonage)
- ix. Check for silt deposits at bottom and wall of the reservoirs as well as Algal and/or iron bacteria growth in the reservoirs and in the distribution systems,
- x. Check for collection of water over the cover slab, cracks, air vent pipe open due to wire mesh damage, no fencing, birds droppings and nests, uncovered inspection man-holes, uncovered outlet pipe/valve boxes, etc conditions that increase chance of contamination treated water in the reservoir
- xi. Check for illegal connections, etc
- xii. From the viewpoints of reducing effects of the climate change, assessing the energy sources of the water pumps is crucial to discourage greenhouse gas emission through use alternate low energy source like solar system. Furthermore, the collection of information related to all the points included above, will allow assessing whether infrastructure is resilient to climate change.

#### 3.2.4. Description of the Distribution systems:

Compared to description of the sources, treatment process and the storage reservoir, understanding the distribution system network is more complex. Description and analysis of the distribution system is more difficult where there is the water supply system history is poorly documented and data is not available. In such condition, involvement of the operation and maintenance workers is important to get information on undocumented system layout and networks. Furthermore, categorizing areas of the town/population that get supply from a particular supply reservoir and distribution pipe grid system is important. Such mapping helps analysis of associated hazards and risks to population living in that specific area.

In particular, distribution system description and analysis requires;

- i. Describe the system flow, type, age, length, size of the materials used (pipe and accessories),
- ii. Describe location where pipe laid and valves are sited like points where pipe crosses the flood drainage ditches, sewer lines, ponds, etc.
- iii. Identify areas where frequent leakage, breakage and supply interruption is occurred (information/data can be obtained from operation and maintenance workers)
- iv. Identify the areas which are likely to be affected by floods due to heavy rainfall

In summary, distribution system description and analysis primarily relies on review of the secondary data (system design) and information from operation workers to update the network system map and identify possible/probable areas of problem (hazards) and associated risks.



### 3.2.5. Description of the Household storage (point of consumption):

As a rule of thumb, utilities take responsibility to ensure water safety until water meter and/or the public stand post (public fountain). After the water meter/public fountain, responsibility to maintain safety of the water falls under the jurisdiction of the household (customer/user). However, there exist potential hazards and contamination risks either from water collection and storage container and/or the water handler her/himself during transportation and storage in the household. Information on hygiene and sanitation behavioral risk factors (hazard events) during water fetching, transportation and household safe water storage practices; hand washing and defecation practices are collected using observation checklists, which is complementary to sanitary survey of water supply systems. Therefore,

- i. Describe type and size of pipes, size and types of the storage/service reservoirs, and any informal connections before the water meter, and water uses
- ii. Describe type and size of the water collection containers (jerry cans, pot, bucket, etc)
- iii. Household sanitation and hygiene practices of the water handlers, and household water storage practices (use of narrow neck, covered, placed off floor, container cleanliness)
- iv. Household water treatment practices and reasons for treating
- v. Test and analysis quality of water at household level and determine level of hazards and associated risks in the household.
- vi. Check for illegal connections and vandalism

### 3.2.6. Additional information during system description and analysis

- i. Describe number of population using that particular water supply, their intended uses, and socio-economic status of the communities,
- ii. Describe service level, and how service addresses needs of disadvantaged groups of population
- iii. Describe equity distribution of water for intended uses and the vulnerability differential between communities,
- iv. Describe the community hygiene and sanitation condition (excreta, waste water and solid waste disposal)
- v. Describe operation, maintenance and system management capacity of the utility
- vi. Furthermore, retrospective climate change related weather data needs to be collected as part of the system description, but this will normally be done by the team responsible of conducting the V&A assessment.

### 3.3. STEP THREE – HAZARD ASSESSMENT, VALIDATION OF EXISTING CONTROL MEASURES AND RISK ASSESSMENT SYSTEM DESCRIPTION

This section provides guidance on how to identify potential hazardous events and how hazards enter into the water supply system. Objectives of hazard assessment, validation of existing control measures and risk assessment include;

- i. To identify specific and potential hazards or dangers that might threaten the safety (microbial and physic-chemical contaminants) and quantity of drinking water supply to identify how and where hazard enters in to the stages of the supply system (hazardous events or causes of hazards) or put at risk the continuity of the supply (e.g. unavailability of water due to drought)
- ii. Identify and determine the effectiveness of existing control measures, and determine whether additional control measures are needed or not
- iii. Identify future areas of improvements and changes to be made to minimize occurrence of hazard events and likelihood of occurrence of hazards so as to safeguard health of the consumers

#### 3.3.1. Identify hazardous events and hazards to water supply system

The system description and analysis provided information on different stages of the water supply system from catchment/source to the point of consumption and potential sources of hazardous events and hazard entry points. Based on information from system description, WSP team identifies the potential hazards, hazardous events, areas where hazard enters into the water supply system (from catchment to the point of consumption) to be assessed in detail during field risk assessment after validation of the effectiveness of the existing control measures.

During hazards assessment, WSP team should consider hazards and hazardous events in pairs and assess risks for each pair. The flowing table (Table 3) illustrates hazards and how (hazardous events) and where it enters at any of steps in the water supply system

Table 3: Hazards, hazardous events and entry points in the water supply system

Steps in the water supply system	Hazardous event (how hazard could enter in to the water supply)	Hazards type (microbial, chemical and/or physical)
Catchment	Agricultural/ Mining activities around the source could result to contamination of pesticides/ chemicals in periods of heavy rainfall	Chemical contamination
Source	Open defecation and garbage disposal in the catchment of the water source and runoff collect human faeces and enters the water source	Microbial and physical contamination

Steps in the water supply system	Hazardous event (how hazard could enter in to the water supply)	Hazards type (microbial, chemical and/or physical)
Treatment unit	Heavy rainfall and the runoff collect silt and enter the treatment work	Physical(Turbidity and pH)
Reservoirs /storage	Microbial (algae) growth in wash-out valves	Microbial
Distribution network	Openly laid pipes, aged pipes and leakage	Physical and microbial
Household (point of consumption)	Collect and store water using dirty and wide necked container	Microbial contamination of the drinking water

### 3.3.2. Hazard analysis

Example of identified hazardous events paired with hazard and condition of existing control measures at the catchment/ source and households

Table 4: Examples hazardous events paired with hazard condition and control measures

Stage	Hazardous events	Nature of hazard	Control Measures of hazardous events	Risk level	Additional control Measures if needed.
Catchment/Source	Open defecation around water sources: runoff washes faeces and enters in to the water source	Microbial	No control measure	High	Building flood diversion ditch; Health education
	Flood/ Heavy rain damage and consequently runoff washed animal and human faeces and contaminate water sources ,	Microbial, Physical (turbidity)	Protection of water sources, treating drinking water and safety storing it at household level	High	Maintaining vegetation and grass; Build flood protection dike uphill of the borehole and rehabilitate the well and repair infrastructures
	Drought resulted in lowering of the ground water table and as a result hand dug and shallow well dried,	Microbial, Physical (turbidity)	No control measure	High	Ensure proper conservation and protection of water sources; Replacement of the hand dug and shallow wells and infrastructures with more drought tolerant/resilient deep boreholes
	Hand pump broken due to continuous pumping and lack of greasing of moveable parts (lack of regular preventive maintenance)	Operational/ physical	No control measure	Medium	Regular inspection and maintenance of the water supply infrastructures

Stage	Hazardous events	Nature of hazard	Control Measures of hazardous events	Risk level	Additional control Measures if needed.
Treatment plant)	Malfunctioning of treatment plant, inadequate dosage and power rationing	physical and chemical	Proactively checking treatment plant conditions and promptly rectifying anomalies observed. Frequent check residue dosage	Medium	
Storage/ reservoir	Poor storage facilities	Microbial on, turbidity	Boiling of water	Medium	Use of safe water storage facilities Jerry-cane
Distribution	Busting and untimely repair of damaged pipes  Illegal and improper connections	Chemical and microbial	Proactively checking conditions of distribution systems and reacting timely to observed situations.  Undertake connections inventory from time to time.	High	
Household (point of use)	Poor storage facilities	Microbial on, turbidity	Boiling of water	Medium	Use of safe water storage facilities Jerry-cane

### 3.3.3. Assessment of risks to the water supply system

After analysis of the effectiveness of the existing control measures, WSP team should conduct a risk assessment to the whole water supply system from catchment to the point of consumption. During this assessment, the team considers all of the hazardous events and hazards identified, consider the strength and weakness (effectiveness) of the existing control measures, and then conduct risk analysis and determine risk levels. The major climate-related risks that affect water supply systems can be grouped under four broad scenarios:

- i. Increasing risk of flooding or increased run-off in some areas that potentially overwhelms current sanitary protection measures, leading to damage or destruction of infrastructure and cross contamination. Increased flooding is likely to derive from more intense rainfall events, from increased average rainfall, or a combination of both.
- ii. Decreasing rainfall or longer periods of low rainfall in some areas potentially resulting in declining surface and renewable groundwater availability or longer droughts, leading to increased challenges to meet demands for water for domestic use or for supporting water-borne sanitation. Decreasing total rainfall in some areas will reduce the capacity of surface water to dilute, attenuate and remove pollution and, together with rising temperatures, will change the patterns of microbial growth in both source and treated waters.
- iii. Increasing rainfall in some areas, potentially leading to long-term increases in groundwater levels, reducing the potential for pathogen and chemical attenuation or removal, and causing flooding of sub-surface infrastructure and potentially rapid shallow groundwater flow



- iv. Higher temperatures and evaporation potentially leading to higher concentrations of biological and chemical contamination.

#### 3.3.3.1 Climate-related risks to water availability and reliability

The WSP manual describes the process for identifying hazards and hazardous events and assessing the levels of risk associated with each hazard. WSPs tend to focus on the hazardous events which impact on water quality. In a broader water resources context, drought related hazardous events, exacerbated by future climate change, can lead to scarcity and reliability risks. WSPs should consider the strategic risks posed by source water scarcity and the competing users of water in a catchment.

Reviewing the outputs from studies such as water resources assessments and basin management plans can be used to identify the longer-term risks to water supply systems. These may include urban development causing increasing water scarcity or pollution as well as future climate change altering water availability amongst others. Where these assessments are available, the WSP team should refer to them as part of the risk assessment process. This may include the following elements:

- i. Assessing the reliability of source yields within years, arising from seasonal variability, and between years arising from drought events;
- ii. Compiling information on the other abstractors of water in the catchment and their patterns of abstraction under normal and drought conditions;
- iii. Identifying trends in land use, pollution discharge, urban development, industrial development, population growth and any other factors which may lead to increased competition for water, or reduced water quality at key water sources; and
- iv. Considering changes in water availability and reliability under different climate change scenarios to highlight potential future risks, as determined by the results of the assessment conducted at climatic/ ecological/ regional level.

#### 3.3.3.2. Climate-related risks to water supply infrastructure

From a DRR perspective, it is essential to consider a range of potential hazardous events that the area might experience. In order to explore the hazardous events and their potential impacts on water safety, civil contingency planners may assist in developing credible hazardous event scenarios for the specific location.

Water supply systems are exposed to a range of climate related hazardous events which can impact on the effective operation and overall structural integrity or water supply system assets. This can range from flooding of treatment works and auxiliary systems such as power supplies, damage of pipework due to flooding, scour and erosion damage at rivers and coastal areas,

Damage to infrastructure will often occur as part of wider disaster events which will cause widespread disruption to power and transport networks which are largely outside the control of the water supplier. In these cases, the assessment of related hazardous events beyond the water system itself will be required in order to gain a full picture of the risks to which water supplies are exposed.

### 3.3.3.3. Climate-related risks to water quality

The effects of climate change can cause problems in water supplies. In general, the types of hazards that are more likely to occur at more hazardous levels within existing water supplies as a result of climate change are those that are exacerbated by warmer, drier conditions combined with more intense precipitation events. Historically, these types of hazards and hazardous events have included factors such as:

- i. Pathogens, e.g. *Cryptosporidium* spp. oocysts, along with particles, e.g. topsoil in runoff, being driven into source waters in higher concentrations due to increased precipitation intensities following prolonged dry periods, or fire damaged forests, with reduced dilution due to lower storage levels.
- ii. Phytoplankton, e.g. toxigenic cyanobacteria, proliferating to higher levels in the slower flowing, lower turnover, warmer conditions within uncovered source water reservoirs.
- iii. Opportunistic pathogens, e.g. *Naegleria fowleri*, proliferating to higher levels in the slower flowing, warmer water with disinfectant residual within closed water storages and distribution systems.
- iv. Chemicals found in many groundwater systems (e.g. arsenic and fluoride), as well as chemicals in wastewater discharges, increasing in concentration due to less dilution and reaching levels of concern.

One of the predicted consequences of climate change is increased periods of water shortage in many parts of the world, and, new water supplies are being tapped in many areas, sometimes for the first time. (In other contexts, water flows might be higher, more variable or subject to more intense precipitation events.) Traditional water sources that have been used for many years are likely to be well-understood with the important hazards, hazardous events and control measures recognized and managed. However, there may often be no local experience with new water supplies and issues relating to new supplies will be context specific. Water management agencies may be unfamiliar with the very different water qualities and challenges involved with new sources. For instance:

- i. Water suppliers familiar with surface water that are forced to bring on groundwater, or vice versa. Surface water supplies rarely contain metals at problem concentrations, but ground waters often do. Similarly, ground waters typically have fairly stable water quality whereas surface water quality can be highly variable.
- ii. Water suppliers familiar with sourcing water from large reservoirs that are forced to bring on river water sources, or vice versa. Some river water supplies rarely contain cyanotoxins at problem concentrations, but reservoir waters often do. Similarly, reservoir waters typically have fairly stable water quality whereas river water quality can be highly variable.
- iii. Water suppliers familiar with relatively clean water that are forced to bring on more contaminated water sources. Water from undeveloped catchments rarely contains hazards at problem concentrations, whereas water sourced from developed catchments often does.
- iv. Innovative water management arrangements may be implemented that introduce new types of hazards and hazardous events. For instance, there may be an increased reliance on recycled water in agricultural and urban settings which might present increased risks of water-related

disease if cross-connected into drinking-water supplies.

Risk assessment uses data collected from the water supply system observation (sanitary surveys to the water supply system from catchment to point of use and water quality test results) and data of the utility and the health offices to determine risk levels, for each components of the water supply system. The approaches involve estimation of likelihood/frequency of a certain event to happen and severity/consequences of the event on the quality and quantity of water, on the water supply infrastructures and/or on the health of the water users. The risk assessment need to involve the whole WSP team as it is depends on the consensus approach. The scoring of risks requires assigning of numbers to different level of likelihood and to levels of severity.

Table 5: Likelihood of the risk and its consequences (severity) and scores assigned to each level

		<b>Severity or Consequence</b>									
		<b>Insignificant or no impact - Rating: 1</b>	<b>Minor compliance impact - Rating: 2</b>	<b>Moderate aesthetic impact - Rating: 3</b>	<b>Major regulatory impact Rating: 4</b>	<b>Catastrophic public health impact - Rating: 5</b>					
<b>Likelihood or frequency</b>	<b>Almost certain/ Once a day - Rating: 5</b>	5	10	15	20	25					
	<b>Likely / Once a week - Rating: 4</b>	4	8	12	16	20					
	<b>Moderate / Once a month - Rating: 3</b>	3	6	9	12	15					
	<b>Unlikely / Once a year - Rating: 2</b>	2	4	6	8	10					
	<b>Rare / Once every 5 years - Rating: 1</b>	1	2	3	4	5					
<b>Risk Score</b>		<b>&lt; 6</b>		<b>6 - 9</b>		<b>10 -15</b>		<b>&gt; 15</b>			
<b>Risk Rating</b>		<b>High</b>		<b>Low</b>		<b>Medium</b>		<b>High</b>		<b>Very</b>	

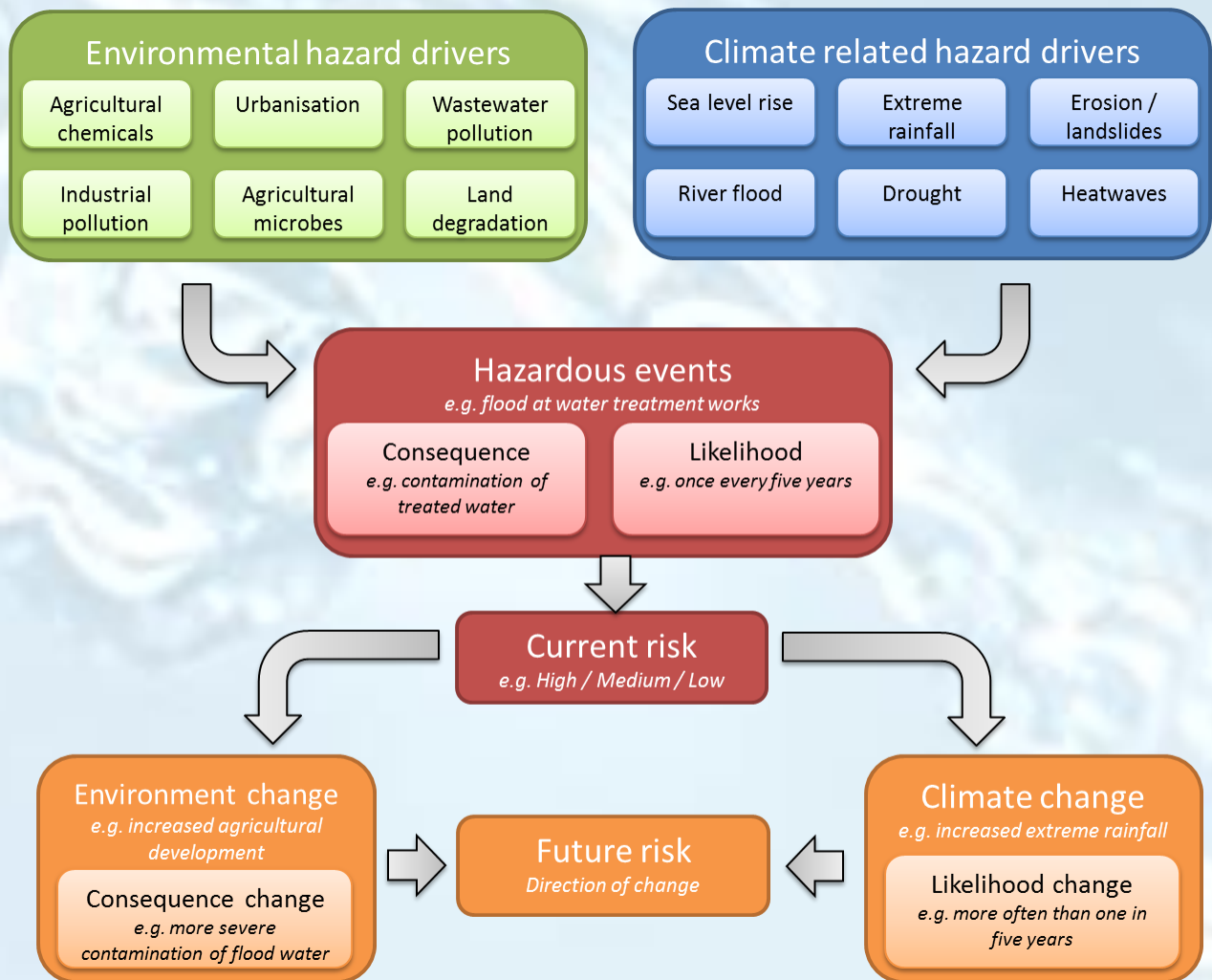


Figure 3: Conceptual flow of activities in WSP risk assessment, extended to consider changes in climate and environment.

### 3.3.4. Impact of climate change on estimates of likelihood

The likelihood of future conditions, or frequency of occurrence, is typically assigned by the WSP team based on their local experience of the frequency of historical incidence. Events that have occurred only rarely in the past in the local context may be assumed to be rare in future, but that requires there to be no fundamental change in the nature of the drivers of the hazardous event.

However, in undertaking risk assessments, the WSP team needs to consider the likelihood of future events, and not be limited to basing likelihood predictions on the past. Some hazardous events will be more likely in future than they were in the past, whilst others might be less likely. For instance, in an area likely to become warmer and wetter due to climate change:

- i. Contamination of source waters due to high intensity rainfall may have been rare in the past and unlikely in a specific context, but might become more frequent in future.



- ii. Failure of water conduits due to freezing may become less common in future due to increased temperatures.

It will be difficult to place firm estimates of likelihood on some scenarios, but hazardous events could simply be classified as low probability / high impact (LPHC) events.

If the WSP team does not consider future likelihoods in its risk assessment, the WSP might underestimate the likelihood and therefore the risk of certain hazardous events, resulting in a sub-optimal allocation of resources.

### 3.3.5. Impact of climate change on estimates of consequence

In undertaking risk assessments, the WSP team needs to consider the consequence of future events, and not be limited to basing consequence predictions on the past. Some consequences are likely to be more significant in the future than they were previously, whilst others might be less significant. For instance, in an area likely to become drier due to climate change:

- i. The consequence of cyanotoxins in source waters might have been insignificant in the past due to regular turnover of the sources, limiting their carrying capacity for cyanobacteria to low densities in a specific context. Elevated and more consequential densities may occur in the future under lower flow conditions.
- ii. The consequence of arsenic from groundwater sources might have been insignificant where that groundwater made up a small contribution to the total quantity of water supplied in the past. The consequence may increase to being more significant in the future if the groundwater begins to make up a greater proportion of the source.

As with likelihood, if the WSP team does not consider future consequence severities in its risk assessment, the WSP might underestimate or overestimate certain risks.

### 3.3.6. Determine effectiveness of the existing control measures

Control measures are required to reduce the climate related risks identified and assessed to acceptable levels. Identifying control measures which manage current and future risks will be required, as well as control measures which take a strategic approach to managing long term future risks. Some of the potential control measures will be the primary responsibility of other stakeholders rather than the water supply authority and so need to be developed in partnership with others.

Following identification of the hazards and hazardous events, WSP team should look into what control measures have been put in place by the utility to remove /prevent or eliminate the impacts of the hazardous events on each step of the water supply systems and to safeguard health of the consumers. Once existing control measures are identified, the WSP team continues to review and validate effectiveness of the existing control measures based on the following measurements and assess potential risks.

- i. Preventing contaminants from entering the source of water
- ii. Removing the contaminants from the water
- iii. Inactivation /killing the hazards (pathogens)

iv. Preventing recontamination of water during distribution, storage and handling

Some risks may be addressed by existing control measures either during intake (e.g. catchment protection), treatment (e.g. reduction of turbidity and killing/inactivation of pathogens by disinfection), at storage reservoir or on the distribution system. Reviews of effectiveness of existing control measure provide information on the strengths and weakness/gaps of the control measures, as well as risks yet not addressed.

Table 6: Examples of hazards and hazardous events that may be exacerbated by climate change and accompanying potential control measures to reduce the level of risk. Note that this table is neither exhaustive nor universal.

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
<b>Enteric pathogens</b>			
<p>Increased temperatures</p> <p>Reduced runoff volumes</p> <p>Increased precipitation intensities</p> <p>Reduced reservoir turnover and depths</p>	<p>Faecal-oral pathogens from faecal waste in source waters and catchments including viruses, protozoa and bacteria e.g. norovirus, <i>Cryptosporidium parvum</i> and <i>Campylobacter jejuni</i>.</p>	<p>Occurring at higher concentrations in treated water due to:</p> <ul style="list-style-type: none"> <li>• Increased release of pathogens due to more intense precipitation causing wastewater containment, treatment and management systems to become less effective</li> <li>• Increased release of pathogens due to more intense precipitation causing greater transport of manure from grazing animals</li> <li>• Decreased dilution, sedimentation and attenuation in source waters due to increased precipitation intensity and increased stratification in storages</li> <li>• Increased transfer of pathogens through treatment systems due to more intense precipitation and reduced storage volumes causing drinking-water treatment systems to become less effective</li> <li>• Selection of less safe alternative sources due to limited water resource availability in safer normal sources</li> <li>• Increased use of source waters for polluting activities due to reduced availability of alternative waters</li> <li>• Cross contamination from</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Minimise sewage and manure runoff from catchment, particularly from human and intensive juvenile stock animal sources</li> <li>• Increase riparian area integrity and vegetation cover</li> <li>• Introduce or enhance wet weather event storage and management capacity of wastewater management systems</li> <li>• Increase setback distance and improved buffering from watercourse to points of faecal matter deposition or storage of effluent</li> <li>• Develop a long term drought management plan</li> <li>• Keep storages as full as possible to maximise detention times</li> <li>• Protect storage and catchment from activities that could introduce pathogens e.g. recreation, grazing in direct proximity to water sources</li> <li>• Reduce impervious surface areas in water catchments to smooth out inflows</li> <li>• Capping unused bores and ensuring current wells are appropriately sealed from surface run-off</li> <li>• For deep wells ensure casing exceeds well below the level of shallow aquifers</li> </ul>

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
		<p>damaged sewage systems or flooding of sewer pump stations</p> <ul style="list-style-type: none"> <li>• Surface water ingress into septic tanks, after flooding events leading to overflow of effluent into streams and rivers</li> <li>• Contaminated surface water entering well heads after large run-off events</li> <li>• Increased lateral flow in soils, after large rainfall events) may increase transport of contaminants, particularly in shallow aquifers</li> </ul>	<p>Treatment controls:</p> <ul style="list-style-type: none"> <li>• Enhance or introduce additional treatment to handle increased pathogen challenge during peak events</li> <li>• Maintain or improve turbidity levels during treatment, particularly during peak events</li> </ul>
<b>Microorganisms proliferating within water storage and distribution systems</b>			
<p>Increased temperatures</p> <p>Reduced water availability</p>	<p>Opportunistic pathogens e.g. <i>Legionella</i> spp.</p> <p>Total coliforms and associated compliance issues</p> <p>Biofilms and heterotrophic plate count bacteria and associated management issues</p> <p>Ammonia oxidising bacteria and associated difficulty maintaining chloramine residual</p> <p>Actinomycetes and associated taste and odour compounds</p>	<p>Occurring at higher densities more often within distribution system due to:</p> <ul style="list-style-type: none"> <li>• Increased water temperature due to environmental warming</li> <li>• Greater difficulty maintaining disinfectant residual due to increase in water temperature</li> <li>• Greater difficulty maintaining disinfectant residual due to reduced water turnover if water use restrictions are in place to respond to reduced water availability</li> <li>• Greater difficulty maintaining disinfectant residual due to decrease in source, and therefore, treated water quality</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Reduce disinfectant demand through optimizing source selection to minimize organic matter in water</li> <li>• Abstract source water from cooler depths</li> <li>• Increase riparian shade plantings around storages</li> </ul> <p>Treatment controls:</p> <ul style="list-style-type: none"> <li>• Reduce disinfectant demand through enhancing coagulation</li> <li>• Increase disinfectant residual concentrations at point of primary disinfection</li> <li>• Introduce or increase secondary booster disinfection</li> <li>• Change to disinfectant with reduced residual decay (e.g. to chloramine from chlorine, but noting the greater difficulty in managing chloramine residuals in many contexts)</li> </ul>



Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
	e.g. geosmin		<p>Distribution system controls:</p> <ul style="list-style-type: none"> <li>• Reduce treated water service reservoir operating levels to reduce hydraulic residence times</li> <li>• Design or modify system to reduce residence times within pipes</li> <li>• Design or modify system to minimise length of shallow or surface pipes (if practical)</li> <li>• Coat exposed pipes and tank roofs with white paint or make from reflective materials and avoid dark colours</li> </ul> <p>Point of use controls:</p> <ul style="list-style-type: none"> <li>• Avoid storing water in containers in direct sunlight</li> <li>• Coat exposed pipes and tank roofs with white paint or make from reflective materials and avoid dark colours</li> <li>• Refrigerate stored water</li> </ul>
<b>Problematic source water algae and bacteria</b>			
<p>Increased temperatures</p> <p>Reduced runoff volumes</p> <p>Increased precipitation intensities</p> <p>Reduced reservoir turnover and depths</p>	<p>Cyanobacteria and associated cyanotoxins, e.g. microcystin, and taste and odour compounds, e.g. geosmin.</p> <hr/> <p>Diatoms and associated taste and odour, e.g. <i>Asterionella</i> spp., compounds and filter blocking diatoms, e.g. <i>Synedra</i> spp.</p> <hr/> <p>Benthic</p>	<p>Occurring at higher densities more often within source water reservoir due to:</p> <ul style="list-style-type: none"> <li>• Increased water temperature</li> <li>• Increased hydraulic residence time due to more prolonged periods of drought</li> <li>• Increased nutrient loads due to increased precipitation intensity</li> <li>• Increased nutrient concentrations due to reduced dilution, particularly from point sources</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Reduce nutrient loads into storages</li> <li>• Establish wetlands and riparian buffer zones to retain nutrients from runoff and minimise soil erosion</li> <li>• Where possible, use selective depth abstraction to source water from reservoir depths that minimise concentrations of hazards</li> <li>• Increase riparian shade plantings around storages</li> <li>• Operate storages and flows to maximise turnover if low</li> </ul>

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
	<p data-bbox="410 296 643 562">cyanobacteria and associated cyanotoxins, e.g. saxitoxins, and taste and odour compounds, e.g. geosmin.</p> <p data-bbox="410 569 643 741">Benthic actinomycetes and associated taste and odour compounds, e.g. geosmin.</p>	<ul data-bbox="678 296 1008 527" style="list-style-type: none"> <li>• Stronger stratification</li> <li>• Changed biological niche leading to changes in the dominant species present to types not previously considered or experienced within the context</li> </ul>	<p data-bbox="1081 296 1390 352">turnover is a key underlying problem</p> <ul data-bbox="1060 373 1432 1104" style="list-style-type: none"> <li>• Keep storages above levels that could lead to significant benthic influence on upper depths if problem arises at lower strata</li> <li>• Introduce artificial mixing to reduce stratification and oxidise nutrients</li> <li>• Dose algacides pre-emptively to keep concentrations below problem levels</li> <li>• Protect storage from activities that could damage macrophytes, e.g. recreation, thereby helping to prevent a shift from aquatic macrophytes to planktonic dominance</li> <li>• Reduce impervious surface areas in water catchments to reduce inflow rates</li> <li>• Cover small storages where the risk is significant</li> </ul> <p data-bbox="1060 1125 1279 1150">Treatment controls:</p> <ul data-bbox="1060 1188 1406 1808" style="list-style-type: none"> <li>• Cease pre-oxidation before filtration to avoid killing cells and releasing toxins and taste and odour compounds</li> <li>• Increase primary disinfection after filtration to inactivate toxins</li> <li>• Optimise coagulation and filtration to remove algal cells</li> <li>• Change to disinfectant with capability of removing toxins and taste and odour compounds e.g. ozonation</li> <li>• Introduce ability to remove toxins and taste and odour compounds, e.g. powdered activated carbon or granular activated carbon</li> </ul>

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
			Point of use controls: <ul style="list-style-type: none"> <li>• Store water in darkness</li> </ul>
<b>Problematic plants</b>			
<p>Increased temperatures</p> <p>Reduced runoff volumes</p> <p>Increased precipitation intensity</p> <p>Reduced reservoir turnover and depths</p>	<p>Aquatic weeds and associated loss of utility of reservoir, e.g. <i>Cabomba</i></p>	<p>Occurring at higher densities more often within source water reservoir due to:</p> <ul style="list-style-type: none"> <li>• Increased light penetration due to decreased turbidity, resulting from less run-off</li> <li>• Increased water temperature</li> <li>• Increased hydraulic residence time due to more prolonged periods of drought</li> <li>• Increased nutrient loads due to increased precipitation intensity</li> <li>• Increased nutrient concentrations due to reduced dilution, particularly from point sources</li> <li>• Stronger stratification</li> <li>• Changed biological niche leading to changes in the dominant species present to types not previously considered or experienced within the context</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Minimise nutrient runoff, particularly phosphorus, from the catchment</li> <li>• Establish wetlands in key catchment locations to retain nutrients</li> <li>• Mechanically harvest weeds from water</li> <li>• Kill weeds using herbicides safe for use in drinking-water</li> <li>• Increase riparian shade plantings around storages</li> <li>• Dose herbicides to keep concentrations below problem levels</li> <li>• Protect storage from activities that could introduce problem water weeds e.g. water-based recreation</li> </ul>
<b>Chemical toxicants</b>			
<p>Increased temperatures</p> <p>Reduced runoff volumes</p> <p>Increased precipitation intensities</p> <p>Reduced</p>	<p>Agricultural chemicals, e.g. Nitrate.</p>	<p>Occurring at higher concentrations in treated water due to:</p> <ul style="list-style-type: none"> <li>• Decreased dilution in source waters due to reduced runoff</li> <li>• Increased intensity of agriculture in areas that are still viable due to drought-related reductions in total</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Minimise agrochemical runoff from catchment or recharge area</li> <li>• Minimise the use of high risk agrochemicals in recharge areas</li> <li>• Limit high intensity agricultural activities in key catchment and recharge areas</li> </ul>

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
reservoir turnover and depths		<p>land area available for agriculture</p> <ul style="list-style-type: none"> <li>• Change to potentially more contaminated water due to increased abstraction and less inflow leading to change of contributing water sources</li> <li>• Selection of less safe alternative sources due to limited water resource availability in safer normal sources</li> <li>• Increased nutrient loads in source waters after large runoff events</li> <li>• Contamination of groundwater due to infiltration of pollutants with large rainfall events</li> <li>• Increased lateral flow in soils after large rainfall events may increase transport of contaminants, particularly in shallow aquifers</li> </ul>	<ul style="list-style-type: none"> <li>• Abstract water from deeper or better confined aquifers</li> <li>• Capping unused bores and ensuring current wells are appropriately sealed from surface run-off</li> <li>• For deep wells ensure casing exceeds well below the level of shallow aquifers</li> </ul> <p>Treatment controls:</p> <ul style="list-style-type: none"> <li>• Introduce reverse osmosis treatment</li> </ul>
	Chemicals from geology in ground water, e.g. arsenic and fluoride.	<p>Occurring at higher concentrations in treated water due to:</p> <ul style="list-style-type: none"> <li>• Decreased dilution in source waters due to reduced inflows or recharge during more prolonged periods of drought</li> <li>• Change to potentially more contaminated water due to increased or over abstraction and less inflow leading to change of contributing water sources</li> <li>• Selection of less safe alternative sources due to limited water resource availability in safer normal sources</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Abstract water from less contaminated sources</li> <li>• Avoid over abstraction that may change contributing source waters to more contaminated ones</li> <li>• Use multiple sources to dilute specific pollutants</li> </ul> <p>Treatment controls:</p> <ul style="list-style-type: none"> <li>• Optimise existing treatment to remove chemicals e.g. coagulation optimisation</li> <li>• Introduce enhanced treatment e.g. pre-oxidation, ion exchange, chemical adsorption or reverse osmosis</li> </ul>



Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
	<p>Disinfection by-products, e.g. haloacetic acids</p>	<p>Occurring at higher concentrations in treated water due to:</p> <ul style="list-style-type: none"> <li>• Decreased dilution of organic precursors in source waters due to reduced inflows or recharge during more prolonged periods of drought</li> <li>• Increased organic matter from phytoplankton due to reduced river flow and increased nutrients concentrations</li> <li>• Increased disinfectant concentrations to maintain residuals under hotter, lower flow conditions</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Minimise nutrient runoff, particularly phosphorus, from the catchment</li> <li>• Establish wetlands in key catchment locations to retain nutrients</li> <li>• Replace vegetation that contributes high levels of organic runoff with less problematic vegetation</li> <li>• Introduce artificial mixing to reduce stratification and oxidise nutrients</li> <li>• Protect storage from activities that could introduce organic matter e.g. water-based recreation</li> </ul> <p>Treatment controls:</p> <ul style="list-style-type: none"> <li>• Optimise existing treatment to remove precursor's e.g. coagulation optimisation</li> <li>• Introduce enhanced treatment e.g. pre-oxidation, ion exchange, chemical adsorption or reverse osmosis</li> <li>• Introduce better optimised disinfection strategies, such as using booster disinfection rather than excessive primary disinfection</li> <li>• Move to using primary disinfectants with reduced disinfectant by-product formation potential, e.g. UV or ozone</li> </ul> <p>Distribution system controls:</p> <ul style="list-style-type: none"> <li>• Reduce treated water service reservoir operating levels to</li> </ul>

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
			<p>reduce hydraulic residence times</p> <ul style="list-style-type: none"> <li>• Move to using residual disinfectants with lower disinfectant by-product formation potential, such as using chloramines rather than free chlorine for maintaining residual</li> </ul>
	Metals released from sediments, e.g. manganese.	<p>Occurring at higher concentrations more often within source water reservoir due to:</p> <ul style="list-style-type: none"> <li>• Reduced dilution from reduced overall rainfall quantity</li> <li>• Stronger stratification and reduced dissolved oxygen penetration due to increased temperature</li> <li>• The formation of acid sulphate soils, due to the exposure and re-wetting of sediments</li> </ul>	<p>Source controls:</p> <ul style="list-style-type: none"> <li>• Manage river and wetland flow regimes to minimise the formation of acid sulphate soils</li> <li>• Abstract source water from depths that minimise concentrations of hazards</li> <li>• Operate storages and flows to maximise turnover</li> <li>• Keep storages above levels that could lead to significant benthic influence on upper depths</li> <li>• Introduce artificial mixing to reduce stratification and oxidise metals</li> </ul> <p>Treatment controls:</p> <ul style="list-style-type: none"> <li>• Optimise existing treatment to remove metals e.g. coagulation optimisation</li> <li>• Introduce enhanced treatment e.g. aeration, pre-oxidation, ion exchange, chemical adsorption or reverse osmosis</li> </ul>
<b>Physical hazards</b>			
<p>Sea level rise due to increased temperatures</p> <p>Reduced runoff volumes</p> <p>Increased precipitation</p>	Salinity	<p>Saline ingress into coastal estuaries and ground waters from due to increased sea levels and/or over abstraction of freshwaters influenced by saline ground waters</p> <p>Increases in evaporation and decreasing recharge may</p>	<ul style="list-style-type: none"> <li>• Maintain critical dilution flows in river and streams</li> <li>• Minimise high saline loads from specific sources entering rivers and streams (for example irrigation drainage or wetland discharge)</li> <li>• In controlled river systems,</li> </ul>

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
intensities		<p>increase the salinity of some groundwater resources</p> <p>Decreased run-off in the headwaters of catchments leading to reduced dilution downstream, where saline inputs are more significant</p>	<p>manage flows to minimise the concentration of highly saline water</p> <ul style="list-style-type: none"> <li>• Maintain or improve landscape vegetation to reduce shallow groundwater salinisation</li> <li>• Control abstraction rates to prevent saline ingress</li> <li>• Recharge aquifers with wastewater to keep back saline ingress</li> </ul>
	Turbidity	<p>Occurring at higher concentrations in treated water due to:</p> <ul style="list-style-type: none"> <li>• Increased intensity of agriculture in areas that are still viable due to drought-related reductions in total land area available for agriculture</li> <li>• Increased turbidity due to more intense precipitation events causing greater erosion of agricultural lands, stream banks and loads from urban storm water</li> </ul>	<ul style="list-style-type: none"> <li>• Minimise sediment loads from agricultural and urban storm water</li> <li>• Stabilise stream bed and banks to minimise erosion</li> <li>• Establish wetlands in key catchment locations to retain nutrients</li> <li>• Increase riparian area integrity and vegetation cover</li> </ul>
<b>General</b>			
<p>Increased temperatures</p> <p>Reduced runoff volumes</p> <p>Increased precipitation intensities</p> <p>Reduced reservoir turnover and depths</p>	Water quality hazards that are present in new water sources	A hazard becomes problematic due to a new water source being used to augment a drinking-water supply or a new water source being used in place of an existing water source (refer above as examples of hazards for which this is a potential hazardous event)	<ul style="list-style-type: none"> <li>• Carefully consider all hazards that might be relevant to the new water source</li> <li>• Undertake baseline water quality testing of the new water source</li> <li>• Review capability of existing treatment systems against the treatment requirements of the new water source and augment the treatment if required</li> <li>• Operate the water source assuming the worst-case for its quality in the absence of knowledge about that quality until new knowledge has</li> </ul>

Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
	Water quality hazards that cause unforeseen incidents	A hazard becomes problematic that was not foreseen and is only revealed after adverse consequences have occurred or are about to occur	<p>amassed</p> <ul style="list-style-type: none"> <li>• Place emphasis on assessing emerging or future risks</li> <li>• Maintain a water quality incident and emergency management plan</li> <li>• Prepare specific contingency plans for foreseeable hazardous scenarios</li> <li>• Introduce available to use alternative sources</li> <li>• Increase treated water storage capacity to allow avoidance of problem periods</li> <li>• Set up systems to enable rapid community alerts regarding boil water alerts and water consumption avoidance advisories and orders</li> </ul>
	Water quality hazards that are present due to new water management arrangements	A hazard becomes problematic due to a new water management arrangement that can lead to new water-related exposures or cross-connections between alternative non-potable water and potable water	<ul style="list-style-type: none"> <li>• Carefully consider all hazards that might be relevant to the alternative water management arrangements</li> <li>• Ensure treatment systems adequately reduce hazard concentrations in the alternative water to allow for both the intended and inadvertent but inevitable uses of, and exposures too, that water</li> <li>• Implement rigorous systems to prevent excessive exposures beyond those intended to the alternative non-potable water supply</li> <li>• Implement rigorous systems to prevent cross-connections or inadvertent tap-ins that could cause the potable water supply to become contaminated by the alternative non-potable water supply</li> </ul>



Climate change impacts	Hazards	Hazardous events	Control measures to mitigate risks
			<ul style="list-style-type: none"> <li>• Operate the alternative water source assuming the worst-case for its quality in the absence of knowledge about that quality until new knowledge has amassed</li> </ul>
	Water quality hazards that arise due to effects on infrastructure	<p>A hazard becomes problematic due to a failure of water supply systems resulting from for instance</p> <ul style="list-style-type: none"> <li>• heat-related power failures and loss of pumping and treatment systems</li> <li>• floods overwhelming treatment systems and assets in general</li> <li>• heat-related asset failures such as increased rate of pipe bursts due to heat and drought-related ground movement</li> <li>• heat-related impacts on water treatment chemicals such as loss of potency of sodium hypochlorite solution</li> <li>• drying landscape leads to cracking of river banks and degradation of bores</li> </ul>	<ul style="list-style-type: none"> <li>• Install backup systems for critical infrastructure and develop backup water supply options where possible to help in the event of system failure</li> <li>• Develop systems to provide safe water in the event of system failure</li> <li>• Store critical chemicals and materials away from excessive heat</li> <li>• Select materials and chemicals that can withstand increased temperatures</li> <li>• Install robust assets and use installation procedures that protect assets to protect from heat-related stresses, ground movements and flood events</li> </ul>

Source: WHO – Guidance of Climate Resilient WSP, 2015

### 3.3.7. Improvement planning

In the previous section (section 3.2.2), the WSP team has identified hazardous events, hazards, and prioritized based on risk levels as well as has evaluate whether the existing control measures are effective to remove hazards from entering the water systems and whether additional control measures /improvement plan is needed or not.

Using information mentioned above, the WSP team can develop detail action plan of actions that address priority risks identified at all steps in the water supply systems. These planned actions could either new /additional to existing control measures and/or strengthening the existing control actions.

Improvement plan needs core and detailed activities under each core activities/actions to be implemented. In addition, there should be responsible body/person to execute core/each detailed

activity and when it is expected to be accomplished and resources required for implementation of the improvement plan (Table 7).

Therefore, it is important to put improvement actions and addressed in an order of urgency based on the risk level, costs of implementation, and time required to accomplish the improvement plans. Thus, it is important to consider alternative and complementary control/improvement actions (multiple barrier approach) that are effective and affordable.

In addition, the whole processes of WSP development, improvement plan of actions and its implementation status should be documented and shared with the utility manager and with other stakeholders' and is important to use the plan for internal and externally review of the successful implementation of improvement actions and its effect on removal of hazard events and its contribution to ensure the intended water quality targets

In conditions where the control measures are difficult to implement within short period of time due to financing, availability of effective technologies, etc the utility can plan for sustainable alternative mitigation strategies such as safe sourcing, and/or use of defluoridation technologies.

Table 7: Water supply system improvement plan of action (Sample)

Hazards	Hazard events (causes)	Risk Level	Description of improvement actions	Implementer	Estimated budget	Implementation Due date	Implementation status
The well does not provide adequate quantity of water and long queue	Water table lowered due to prolonged drought	High	Find alternative /complementary water source	Utility Manager	50 Million	6 months	
Microbiological contamination of drinking water	Household store water in dirty, wide-necked container	High	Community/HH education and awareness creation on safe water storage practices  HH water disinfection  Storage container clean-up campaign	Health officer	300 ,000	One week	
No free chlorine residual at outlet of the storage reservoir	Adequate quantity of chlorine is not added by the operator due to lack of knowledge and lack of guideline	Medium	Train to the operator  Provide standard operation procedure  Monitor compliance	Utility technician	5,000	Two weeks	

Furthermore, the impacts of climate change on long-term plans should be considered. Some control measures in the implementation/ upgrade plan will manage existing risks over short time scales and can be periodically reviewed and adjusted when WSPs are reviewed. Other measures, such as capital infrastructure upgrades and new supply sources, may be much longer lived. Considering climate change and other risks associated with rising demand and pollution loading will be important in these long-lived aspects of improvement and upgrade plans. Old infrastructure assets require substantial capital investment and will likely be operated for many decades. As a general approach, adaptation strategies for water system infrastructure may require actions such as: designing adaptable infrastructure; building in safety factors to infrastructure to accommodate uncertainty in future climate; utilizing a range of options to achieve an outcome (e.g. diversifying the use of water sources); and supporting infrastructure with non-structural measures such as tariffs and information.

### 3.4. STEP FOUR – MONITORING

Monitoring is essential component of the WSP to verify whether or not the control measures are adequately effective. It involves regular assessment of the effectiveness of the planned control measures, and timely implementation of the improvement plans to ensure consistent supply of safe drinking water.

Monitoring of the water safety plan has two components namely, operational monitoring and verification (or compliance) monitoring. While operational monitoring is conducted by the WSP team (the utility), verification monitoring will be conducted by the local government authority/regulatory bodies. Operational monitoring includes defining and validating the monitoring of control measures and establishing procedures to demonstrate that the controls continue to work.

#### 3.4.1. Operational Monitoring

The objective of operational monitoring is to periodically assess the effectiveness of the planned control measures. It involves defining corrective actions for situations when target conditions are not met to ensure consistent supply of safe drinking water in adequate quantities.

Thus, under this section guidance is given on establishing plans and procedures to measure effectiveness of the control measures, i.e. whether it is performing as intended (i.e. meeting critical limits or target conditions) as determined through water quality testing and/or sanitary inspections..

Water Safety Plan team is expected to define and document **what, how, when** to monitor the control measures and **frequency** of routine monitoring and **who** conducts the monitoring activities, and use of the monitoring for continuous improvement of the water supply system.

**What to monitor:** monitoring is important to check;

- i. The quality of the water supplied to the users comply with the national drinking water quality standard specification (TWQS, 2008)
- ii. Treatment works, disinfection equipments, reservoirs, distribution systems and household water treatment and safe storage practices are in proper running conditions
- iii. That the control measures are working effectively
- iv. That standard operating procedures are followed

**How to monitor:** methods of monitoring could be:

- Water quality tests to check the quality of drinking water comply with national drinking water quality standard specifications (TWQS, 2008). Conduct sanitary inspection to check for improvements made on the water supply system in comparison to conditions before the plan

**When to Monitor:** Frequency of monitoring could be set on daily, weekly, monthly, quarterly, or on an annual basis depending on the urgency to remove hazardous events and to meet set standards. For example, operational monitoring of the disinfection unit in the treatment processes need strict monitoring of the critical limits set for **pH** and **Temperature** of the water and the **correct dose of chlorine** and concentration of **free residual chlorine** before water entering distribution system.

Deviation from the critical limits (or target conditions) usually requires urgent corrective action to block supply of unsafe water to the community and to restore the proper functioning of the control measures.



Whereas, other units in the water supply system such as water source catchment and service/ supply storage reservoirs may need less frequent monitoring visits.

In summary, operational monitoring is important to check and confirm that, the planned control measures are working properly and effectively remove identified hazards and risks (physical, bacteria or chemical) from the water supply system. These can be done by; (REVISE THE THREE PARAGRAPHS)

- i. Regular checks and observations including sanitary inspection to the critical control points in the water supply systems.

**Box 2: Critical limits (or target conditions):** is measure of control measures performances that can be objectively assessed by standard techniques (lab test) and by direct observation

- It is a level which indicates water quality/safety has been compromised and that corrective action should be taken.

For example, the utility can set critical limits such as;

- The filtration unit should have a critical limit /performance to reduce bacteria load and turbidity to less than 5 NTU before passing water to chlorination unit,
- Concentration of free residual chlorine at public stand point/consumer tap should not be less than 0.2mg/L,
- No faecal coliform bacteria in the water tap at household level
- Range of pH limits for effective chlorination
- Access port on storage tank closed and locked
- Area around the water source free of polluting sources (e.g. latrine or garbage disposal)

- ii. Laboratory testing for indicator micro-organisms and suspects of chemical hazards and analysis of the critical parameters to check against critical limits (see table 9)
- iii. Analysis of reasons (shortcoming and challenges) for control measures are not implemented as planned or not effective and identification of future corrective actions.

The following table describes what to be done, frequency and responsible body being parts of and operational monitoring of WSP (Table 8).

Table 8: Frequency of operational monitoring of the water supply systems, critical limits and possible corrective actions

Where	Climatic event	What	When	Who	Critical limits	How (methods of monitoring)	Corrective actions if critical limit surpassed
Source (intake chamber)	Flood/ severe drought	Turbidity	Seasonally	Technician	Less than 1000 NTU	Conduct Visual observation and Water quality test	Divert flood water immediately and suspend raw water harvesting until turbidity drops below critical limit
	Floods	Fence around intake	Weekly	Technician	Intact and gate secured	Conduct Visual observation /inspection	Repair compromised fencing and/or secure gate
Clear water tank (outlet)	Flood/ severe drought	PH	Weekly	Technician	pH: 6.5-8.5	Conduct Water quality test	Investigate change in pH
	Flood/ severe drought	Turbidity	Weekly	Technician	<5 NTU	Conduct Visual observation and Water quality test	Confirm water treatment plant performance and check for leaks and breaks in pipe line
	Flood/ severe drought	Chlorine	Weekly	Technician	Cl <sub>2</sub> : 0.6-0.8mg/L	Conduct Water quality test	Check and adjust chlorine dose as needed
Distribution network	Floods	Leakage and vandalism	Daily/ad-hoc	Technician	Fault connection, breakage and exposure to run off and damage	System observation / inspection	Maintenance/ rehabilitation of the distribution network
Consumer tap (5 taps each time)	Floods	pH	Weekly	Technician	pH: 6.5-8.5	Conduct Water quality test	Investigate change in pH
	Floods	Turbidity	Weekly	Technician	<5 NTU	Conduct Visual observation and Water quality test	Confirm water treatment plant performance and check for leaks and breaks in pipe line
	Floods	Chlorine	Weekly	Technician	Cl <sub>2</sub> : 0.2-0.5mg/L	Conduct Water quality test	Check and adjust chlorine dose as needed

Source: Adapted from WHO Water Safety Plan Manual (WHO 2009)

Table 9: Recommended minimum sample numbers for faecal indicator testing in distribution systems

Type of water supply and population	Total number of samples per year
Point sources	Progressive sampling of all sources over 3- to 5-year cycles (maximum)
Piped water supply	
<5000	12 (1 sample per month)
5000-100,000	12 per 5000 population
>100,000-500,000	12 per 10,000 population plus an additional 120 samples
>500,000	12 per 50,000 population plus an additional 600 samples

Source: Tanzania Standard for Drinking (potable) Water, (TZS789):2008

### 3.4.2. Verification Monitoring



Figure 4: Verification Monitoring, adopted from WHO -WSPs training manual 2012

Verification monitoring confirms that water quality targets or objectives are being achieved and maintained and that the system as a whole is operating safely and the WSP is functioning effectively. It is typically based on compliance monitoring, internal and external auditing of the adequacy of the WSP and adherence to operational activities, and checking consumer satisfaction. In auditing, sanitary inspection formats are often a useful tool for confirming that measures put in place effectively control previously identified risks.

For realization of verification monitoring establish a reliable system for information exchange with relevant stakeholders. Verification includes;

- i. Compliance monitoring: use water quality parameters through water quality testing to confirm that water quality standards are being met. This can be done by specific water utility and by water basin officers. Compliance monitoring requires monitoring plan that include; selection of location where to collect samples, determination of frequency of sampling/testing, documentation/recording and reporting of water quality test results. Water quality surveillance will be employed for compliance monitoring. It is not only limited to water quality testing but also include regularly monitoring of incidence/prevalence of water-borne diseases and analyze trends. The water quality test is being made will include:
  - a) Microbial quality (indicator bacteria *E. coli* or thermo-tolerant coliforms, viruses or protozoan of faecal origin, etc at representative control points in the water supply system).
  - b) Physico-chemical quality parameters such as free residual chlorine, pH, turbidity and nitrate are regularly monitored. Other toxic chemicals such as fluoride, arsenic, iron, etc are tested at the beginning of the development of the water supply project and monitored with less frequent intervals to check any increase of their concentration levels and effectiveness of the chemical removal technologies if present.



- ii. WSP water quality auditing: will be carried out by Local Government Authority (LGAs) and Regulatory bodies. Auditing will be carried through visual observations using sanitary survey checklist and laboratory water quality tests to determine the effectiveness of the WSPs.
- iii. Verification process also encompasses assessment of communities' (water users') satisfaction with the quality/safety, quantity/adequacy, reliability, continuity, and cost of the drinking water through regular water users' satisfaction surveys. It is to be noted that, water users may divert to alternative unsafe water sources if their voice is not heard. Assessment of consumer's satisfaction will be done by both utility (internal) and LGs and regulatory bodies (external).

### **3.5. STEP FIVE – MANAGEMENT AND COMMUNICATION**

#### **3.5.1. Development of the management procedures**

Water safety plan includes establishment of clear management procedures to document actions taken when the water supply system is operating. The standard operation procedures (SOPs) are operational procedures (system operational manual) used both during normal conditions including on how to implement system upgrading and/or improvement (corrective actions). It is also used during incident events situation such as flood and drought and it includes lists of activities to be conducted by utility staff, responsibilities of the utilities and other stakeholders.

The following are examples standard operation procedures (operators working manuals)

#### **3.5.1. Operational Procedures under normal conditions**

- i. Prepare/update operational manual that is used at the stage of raw water intake and pre-treatment, screening of raw water intake, calibration of meter to measure water flow, and switching and increasing/decreasing pump operation.
- ii. Update procedure for dosing of coagulation/flocculation chemicals and disinfection/chlorination
- iii. Prepare/update procedure for record keeping and reporting (list of reportable key parameters, failure reporting forms, users' claim form, etc)
- iv. Prepare/update water sampling and testing procedure,
- v. Prepare/update manual/procedure on certification of competence (COC) for water supply system operators, and water quality analysts
- vi. Develop system of communication between utility and health sector/regulator particularly on sharing of lab test/analysis and sanitary survey results

#### **3.5.2. Management procedures to deal with incidents**

- i. In addition to climate and weather information collected from the metrological agency, organize community consultation workshop and identify trends of climatic changes that occurred during the past years/decades based on the histories and experiences of the elders and/or based on meteorological data, make prediction for possible changes in the water system and establish baseline for future monitoring
- ii. Prepare/update contact information of key personnel including operators and managers and other stakeholders
- iii. Prepare/update clear description of actions required in the events of deviations from critical limits
- iv. Prepare/update location of backup equipments

Depending on the type and complexity of emergency situation, develop/update the response action which could vary from;

- i. Modification of treatment of existing sources, or temporary use of alternative sources with appropriate water treatment, or water tracking during worst water scarcity.
- ii. In case of gross contamination due to flooding and damage to different parts of the water supply systems
- iii. Increase disinfection points including at treatment tank, distribution lines, and at household levels.
- iv. Properly document these emergency response actions in the emergency management procedures.

In addition, address the following issues in the emergency communication procedure;

- i. Prepare response and monitoring actions,
- ii. Identify responsibilities of internal and external stakeholders,
- iii. Develop/update communication strategies (rules for internal information sharing/exchange mechanism, with the regulatory and with media and the public),
- iv. Develop/update user manual for distribution of emergency supplies, surveillance procedures, etc

### 3.5.2. Development of the WSP supporting programs

Development and availing of the standard operational procedures (user manuals) for implementation of WSP under normal condition and during incident condition is not sufficient by itself. Thus, there should be activities that support the utility staff and managers develop necessary knowledge, skills, and commitment to develop and implement water safety plan approach, and capacity to manage water supply systems to deliver safe water. Therefore, need based designing and implementation of the WSP support programs including in-service trainings, research and developments are important.

Therefore, start supporting programs from simple actions;

- i. Organize sensitization workshop for key stakeholders on the existing regulations/standards and their legal responsibilities,
- ii. Organize in-service training for laboratory professionals/analysts on quality control/calibration of testing equipments, and for system operators on calibration of monitoring devices/equipments and on the preventive maintenance.
- iii. Review of existing operators' training curriculum, and develop standard operators training program and manuals and train new operators (pre-service and in-service training programs) by employing cascaded training approaches (master ToT at national and regional level, then sub-regional, then training of utility operators and managers)

- iv. Organize in-service/refresher training for system operators and managers of the utility on the standard operation procedures.
- v. Strengthen hygiene and sanitation promotion interventions to reduce contamination risk at source, in the distribution systems and at household level
- vi. Identify potential areas of water sources and the supply systems that are likely to be affected or damaged by possible disasters (flood) and prepare necessary protective/preventive measures including training of operators, and sensitization of communities.
- vii. Strengthen soil and water conservation (watershed management) interventions conducted by agricultural sectors and by the communities to improve water storage/recharge through development of recharge ponds and contour trenches
- viii. Establishment of the water quality monitoring/surveillance laboratories following WSP implementation scale up program
- ix. Furthermore, identify researchable issues to generate evidences for informed decision making including;
  - a) Testing/adoption of the best practices,
  - b) Changes in the concentration of chemical hazards due to climate change,
  - c) Changes in level of operator's turnover/job satisfaction and training needs,
  - d) Level of customer/water users' satisfaction,
  - e) Changes in the service down-time rates and water wastage rate by service zone,
  - f) Changes in the pattern of WASH borne diseases (under-five diarrhea),
  - g) Changes in water sources resilience to climate change (increase in ground water recharge and reduced impacts of extreme weather events )
  - h) Assessment of the customers' willingness to pay to increase billing rate to improve cost recovery for operation and maintenance, etc.

#### 3.5.2.1. Consider climate-related emergencies when developing management procedures.

In many cases, the new water supplies or novel water management arrangements are implemented in an emergency situation, not allowing time to properly understand and manage the risks arising. For instance, existing treatment plants, designed for one type of water, may be faced with treating a very different type of water, and may not do so adequately. Therefore, early preparedness greatly assists with the mitigation of drinking-water quality risks that might arise due to climate change. There may be years of preparation required to examine the quality of alternative source waters and establish and implement the source water management and treatment requirements for the new sources. For all water supplies in areas that are likely to be affected by climate change, good forward planning is essential. Forward planning should involve assessing water supply options from a quantity and a quality perspective. This may include undertaking baseline monitoring and an assessment of activities taking place in the catchment to establish source water conditions and quality.



The overall WSP might include potential control measures for the alternative water sources that are to be accessed in an emergency. During a disaster it is probable that the civil protection services will seek advice from the water supply organisation on providing safe supplies during the emergency if normal supplies are disrupted.

WHO and the Water Engineering Development Centre (WEDC) have prepared a series of technical notes relating to the provision of safe water and sanitation in emergencies<sup>1</sup> (WHO, 2013). These notes provide practical, evidence-based recommendations in responding to immediate and medium-term water, sanitation and hygiene needs of populations affected by emergencies. The notes are relevant to a wide range of emergency situations, including both natural and conflict-induced disasters. They are suitable for field technicians, engineers and hygiene promoters, as well as staff from agency headquarters. The notes cover:

1. Cleaning and disinfecting wells.
2. Cleaning and disinfecting boreholes.
3. Cleaning and disinfecting water storage tanks and tankers.
4. Rehabilitating small-scale piped water distribution systems.
5. Emergency treatment of drinking-water at the point of use.
6. Rehabilitating water treatment works after an emergency.
7. Solid waste management in emergencies.
8. Disposal of dead bodies in emergency conditions.
9. How much water is needed in emergencies.
10. Hygiene promotion in emergencies.
11. Measuring chlorine levels in water supplies.
12. Delivering safe water by tanker.
13. Planning for excreta disposal in emergencies.
14. Technical options for excreta disposal in emergencies.
15. Cleaning wells after seawater flooding.

It is good practice to stress-test emergency response plans as through role-play and “sunny-day” exercises. The WSP team could additionally identify opportunities to contribute water safety inputs to emergency exercises organised by others (e.g. a major flood incident exercise).

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<sup>1</sup> [http://www.who.int/water\\_sanitation\\_health/publications/technotes/en/](http://www.who.int/water_sanitation_health/publications/technotes/en/)

### 3.6. STEP SIX – FEEDBACK AND IMPROVEMENTS

#### 3.6.1. Periodic reviews of water safety plan

Water safety plan is a living document and is subject to accommodate changes and has to be revised periodically. Depending on the nature of hazard events and associated risk level, some activities outlined in WSP may be implemented as urgent as possible in days or weeks, and other may take long time (months, years) to be implemented. Therefore, WSP team should meet together and review the plan and its implementation processes under normal condition or after managing incidents, and learn from experiences and from new procedures.

In summary, WSP review helps to identify lessons on successes, failures/weaknesses, challenges encountered and how challenges are solved, and important issues missed during planning, and it serves as a basis for upgrading/improvement of the WSP including identification of new risks to existing water supply system and/or new water supply water sources connected to the existing system and designing of associated control measures and corrective actions, and monitoring systems. Furthermore, WSP quickly become out of date through

- i. Catchment, treatment and distribution changes and improvement programmes, which can impact on process diagram and risk assessment.
- ii. Revised procedures
- iii. Staff changes
- iv. Stakeholder contact changes, etc.

Therefore, WSP review should be conducted regularly so as to ensure the guideline is up to date and accurate. The procedure will also need a site visit to see what is happening at the ground.

The WSP team should convene

- **Every six months** (Mid year) to assess progresses made on implementation of quick wins and solve ambiguity/confusions related to WSP implementation
- **Every year** to identify successes, challenges and learn from experiences and update the WSP
- **Every three years** to review the whole processes of WSP implementation, outputs, and its effectiveness from the view points of ensuring water safety and meeting health based targets.

The following measurements can be used to review operational effectiveness of the WSP;

- i. Improvement in water quality and quantity
- ii. Improvement in operation, maintenance and management capacity of the utility
- iii. Improvement on customers' satisfaction and confidence on the utility's services
- iv. Improvements in household safe water management practices
- v. Reduction in prevalence/incidence of diseases attributable to unsafe water
- vi. Improvements in continuity of the water supply (reduction in down time/incidents of supply interruption)
- vii. Improvements in the commitment of operators/managers and job satisfaction
- viii. Examine the extreme climate events ( floods and drought)

During the meeting, the following checklist will provide basic input for review

- i. Notes of the last meeting
- ii. Notes of any interim review

- iii. Changes of the membership of the WSP team
- iv. Changes in catchment, treatment and distribution
- v. Review of operation data trend
- vi. Validation of new control
- vii. Review of verification
- viii. Internal and external audit report
- ix. Stakeholder communication
- x. Customer complaints
- xi. Number of emergency and incidents
- xii. Date of the next meeting

### 3.6.2. Revision of the water safety plan following an incident

Incidents cause damage to water supply systems or compromise quality of water and consequently cause an acute or chronic threat to public health. To avert these threats, WSP implementation has proved to have benefits in reducing incidences of the diseases outbreaks attributable to unsafe water, in improving the capacity of the utilities to anticipate and take preventive measures before catastrophic effects of flood and drought on the water supply systems in general and water quality in particular. In spite of necessary preparedness and response plan made by the government, WASH emergencies may occur and usually affect water supply systems in urban settings.

It is importance to urgently review WSP implementation following emergency so as to address newly emerging hazards and issues related to adequacy of response actions. In addition, post emergency joint review is important to document best practices; identify gaps to be considered/filled in the future as part of preparedness plan. These might include further risk assessment, revision of operating procedures, and/or training of operators on the possible causes of incidents and emergencies, etc that to be incorporated in the revised Water Safety Plans.

The following questions may be asked to provide basis for investigation of incidence, emergency or near miss

- i. What was the root cause of the problem?
- ii. Was the cause of the hazard already identified in the WSP risk assessment?
- iii. How the problem was first identified and recognized?
- iv. What were the most essential action required and were they carried out?
- v. If relevant, was appropriate and timely action taken to warn consumers and protect their health?
- vi. What communication problems arose and how were they addresses?
- vii. What were the immediate and long term consequences of the emergency?
- viii. How can risk assessment /procedures/training/communications be improved?
- ix. How well did the emergency response plan function?

Therefore, post emergency WSP implementation review shall consider the follow issues;

- i. Determine root causes of the emergency problem (e.g. causes of outbreak, and damage to water system)
- ii. Check/verify whether the causes were identified (being one of the hazards) in the previous risk assessment, and whether possible occurrence of the problem is recognized in the previous WSP
- iii. Check /verify whether proper control actions are adequately and timely implemented
- iv. Check/verify if there was communication gap and solutions sought

- v. Determine the immediate and long-term consequences of the emergency (morbidity, mortality, water system breakdown, dissatisfaction of water users and loss confidence on the service quality, etc)
- vi. Identify future areas of improvement/ additional actions such as risk assessment, training of operators, communication means, capital investment, improved monitoring, regulation etc to be incorporated in to revised WSP and future emergency plan
- vii. Accordingly revise/update the WSP standard Operating Procedures during emergency conditions.
- viii. Develop early warning system, communication strategy and preparedness plan on how to supply safe water to the community during emergency

Following an incident, emergence or near miss the following checklist may be useful to revise the WSP

- i. Accountabilities and contact details for key personnel, usually including other stakeholders and individuals, are clearly stated;
- ii. Clear definition of trigger levels for incidents including a scale of alert levels (e.g. when an incident is elevated to a boil water alert); Review whether the management procedures were appropriate for the incident and if not, revise accordingly;\_\_
- iii. Standard operating procedures and required equipment, including back-up equipment, are readily available, and relevant;
- iv. Relevant logistical and technical information is in hand and up to date;\_\_
- v. Checklists and quick reference guides have been prepared and are up to date;\_\_
- vi. Does the risk assessment need revising? \_\_
- vii. Do procedures/ training / communications need improving? \_\_
- viii. Has the incident shown the need for an improvement programme?
- ix. If the incident was related to climate event, the early warning system should be clearly revised



## **CHAPTER FOUR: INSTITUTIONAL FRAMEWORK FOR WSP IMPLEMENTATION**

### **4.1. INSTITUTIONAL FRAMEWORK**

Water sector plays a leading role and responsible for the climate resilient water safety plans implementation both in the urban water utilities and rural community managed water supplies. However, management and administration of land around the water source catchments, and development activities in the catchment zones, and removal of the hazards/contamination risks from source to point of use are not under the sole management of the water sector.

Therefore, implementation of the WSPs needs multi-sectoral coordination at all administrative levels, and technical and management inputs of professionals from catchment authorities/agriculture, water resource, utility, health, education, regulatory bodies and of the development partner organizations. Thus, the existing WASH coordination mechanisms expected to play significant role in the scale up of the water safety plan implementation being an integral part of one WASH national program.

However, development and implementation of the WSPs by the urban utilities and rural community managed water supplies need strong technical support by the technical working group (TWG) at all levels.

### **4.2. ORGANIZATION OF THE WSP IMPLEMENTATION**

Country wide WSP implementation is technically supported by the National WSP technical working group (N-WSP-TWG) composed of senior professionals from water, health, environment/meteorology, hydrology/climatology, agriculture, with expertise in designing of the water supply systems, water treatment works operation and maintenance, water quality monitoring/analysis, natural resource/watershed management, environmental health, vulnerability and adaptation assessment in relation to climate change, and regulation of the standards. In addition, the national TWG encompasses donors, UN agencies and international NGOs working on WASH and promotion environmental protection

- i. Development/updating of the WSP implementation guidelines and training materials
- ii. Development/customization of general standard operating procedures/manuals specific for utilities managed urban water supplies,
- iii. Organize, coordinate and facilitate capacity building training for the regions/major utilities, universities/TVETS, and for regulatory bodies
- iv. Identify issues to be researched, and technical guidance through regular supportive supervisions and report feedback, and review meetings to regional TWG on WSP monitoring
- v. Resource mobilization and nation- wide coordination of WSP implementation scale-up
- vi. Collect WSP implementation reports from the regions and federal town urban utilities; make review of the effectiveness and impacts of WSP implementation at national level.
- vii. Coordinate national drinking water supply system vulnerability and adaptation assessment or support the regions on conduction of regional Vulnerability and Adaptation assessment
- viii. Coordinate the establishment of systems for compliance monitoring at national, regional and district levels.

- ix. Facilitate planning and implementation of compliance monitoring to federal town utilities managed water supplies and, facilitate dissemination of results of the monitoring to National stakeholders
- x. Support the regions by timely providing national forecast on extreme weather events (e.g. droughts or floods).

### **Regional WSP Technical Working Group (R-WSP-TWG)**

Country wide WSP implementation is supported by the regional WSP technical working group (R-WSP-TWG). Professional mix of the regional technical working group is the same with national working group. However, representation of the partner organizations participating may differ from region to region. Functions of the regional technical working group are described as follows;

- i. Sensitization of the regional stakeholders on Concepts and benefits of WSP and its appropriateness to address risks posed by climate change
- ii. Provide technical support to the regional and sub-regional big town/urban utility on the formation of WSP team, capacity building training, and during WSP development and implementation
- iii. Show cases and mobilize local resources for WSP implementation
- iv. Strengthen water quality analysis capacity of the urban utilities and quality monitoring/surveillance capacity of regional laboratories
- v. Provide research support to the big, medium and small town utilities
- vi. Collect WSP implementation reports from the medium and small town utilities and make review of the effectiveness and impacts of WSP implementation at national level.
- vii. Organize annual WSP implementation reviews, document best practices, lessons and share with other regions
- viii. Facilitate establishment networks between urban utility operators
- ix. Facilitate planning and implementation of compliance monitoring to regional/zonal town utilities managed water supplies and, facilitate dissemination of results of the monitoring to regional/zonal stakeholders
- x. Conduction of regional climate change vulnerability and adaptation assessment to drinking water supplies.
- xi. Facilitation of access to regional forecasts of e.g. droughts and floods.
- xii. Perform a hydrology modeling for the region.

### **Utility WSP team**

WSP team is multidisciplinary professionals' team formed by the water utility from utility, health, agriculture/natural resource management and socio-economic studies and planning who have experiences and expertise on watershed management, water supply system design, operation and maintenance, water quality analysis, health and socioeconomic dynamics of the population. Manager of the utility play a coordination role to WSP team.

### **Responsibilities of the WSP team**

- i. Prepare detail activity, milestones and logistics plan for development of Water Safety Plans.
- ii. Review/analysis of existing documents including system design and layout, records and reports on operation and maintenance activities
- iii. Conduct site visits from source to point of use, observe operational practices, identify potential sources of hazards, hazard events, and prepare map of the water supply system

- iv. Map hazardous events, identify and validate existing control measures, analyze risks (considering likelihood and consequences), and plan improvements needed to reduce risk to acceptable levels
- v. Establish operational monitoring plans for each control measure (including corrective actions)
- vi. Conduct field visit periodically to check for proper implementation of operational and observation/inspection of implementation of corrective measures from source to point of use
- vii. Conduct customers' satisfaction survey using qualitative and quantitative techniques
- viii. Provide management support to the utility operators and water quality analysts including facilitation of development/updating of the standard operating procedures (normal and emergency situation), emergency response plans and training of operators
- ix. Produce and submit monthly, quarterly and annual performance reports to the next higher TWG and the TWGs send back report feedback with recommendation
- x. Conduct annual WSP implementation reviews
- xi. Conduct quarterly and biennial reviews as well as following incidents to evaluate effectiveness of WSPs and document practical lessons and share with stakeholders

### 4.3. WSP TEAM SELECTION CRITERIA

The WSP team should be composed of professionals with adequate knowledge and experience of the water supply system from catchment and point-of- consumption and have an authority to prepare water safety plan and implement identified improvements and changes. In addition, the team should comprise other organizations that have stake in the catchment (watershed) and on the water use and quality. Specification of the responsibilities of the team member is important for labor division and team management.

- i. Authority to approve improvements or changes identified in the water supply system (to decide to make decision about budget, devoting staff time, on training, etc)
- ii. Knowledge and experience of the catchment, issues and concerns that may exist in the watershed
- iii. Knowledge and experience with water supply treatment processes and water supply system operations (workers responsible for day to day operation of the water supply)
- iv. Knowledge and experience of water supply infrastructure design and layout (know about the history of the water supply system such as water source recharge to maintain quantity)
- v. Knowledge and experience of water quality monitoring and surveillance processes
- vi. Knowledge and awareness of local health issues associated/attribution to drinking water supply
- vii. Understanding of risks associated with various stages of the water supply systems
- viii. Knowledge of trends of the climate change in the area and how it affects the water supply systems
- ix. Donor agencies and NGOs supporting the government on improvement access to safe and adequate water supplies.

Sr. No	Name	Organization	Position	Areas of responsibility in the team	Address (telephone and e-mail)



## 4.4. WSP IMPLEMENTATION TOOLS

### 4.4.1. Sanitary survey format

The Urban utility managed water supplies have multiple sources including surface water, motorized deep boreholes, and gravity springs, combined and connected in the same grid and supplied to the population from the same reservoir using through the same pipe system connected to the public fountain and the households. Thus, sanitary survey tool kits that encompass multiple sources, treatment plants, reservoir, distribution networks including household connections and public fountains will be developed/adapted from first edition drinking water quality guidelines, volume 3, (WHO 1985) as an addendum to this implementation guideline.

### 4.4.2. WHO/IWA (2012), WSP quality assurance tool

Spread sheet developed by the WHO/IWA version 1.3 for water safety plan quality assurance is adopted and used to assess the performances of the water safety plans implementation.

### 4.4.3. Sample WSP team training program

Training program on development and implementation of water safety plan for members of the urban utility managed water supplies WSP team

	Topics and training Methodology	Time
Day 1	<ul style="list-style-type: none"> <li>• Introduction to the training workshop</li> <li>• Brainstorm, explain/discuss the national water and health policies specific to water safety, national water quality standards and targets, Climate change/weather variability and its effect on the drinking water supplies (Introductory module)</li> <li>• Team dynamics, Team forming, roles, and leading team work towards performance (Module 1)</li> </ul>	1 hr 2 ½ hrs 1 hr
Day 2	Module 2, 3 and 4 Brainstorm, explain and discuss using written documents	7 hrs
Day 3	Module 5, 6 and 7	7 hrs
Day 4	Module 8, 9, and 10	7 hours
Day 5	Module 11 and 12 Orientation to field work and sanitary survey tools	4 hours 4 hours
Day 6	Practical field visit and exercise <ul style="list-style-type: none"> <li>• Field visit to selected community managed water supply and conduct system description, identify hazards and hazard events and existing control measures from catchment to point of use</li> <li>• Discuss in group: characterize risks and evaluate effectiveness of the control measures</li> <li>• Explain and discuss on how to develop and implement an incremental improvement plan,</li> </ul>	8 hrs



#### 4.4.4. WSP implementation Monitoring and Evaluation Indicators (result chain)

Table 10: Implementation, monitoring and evaluation indicators

Level	Benefits of WSP implementation	Performance indicators /target	Data sources and reporting mechanism
Impact	<ul style="list-style-type: none"> <li>Improved health status and productivity of the population</li> </ul>	<ul style="list-style-type: none"> <li>Reduced incidence and prevalence of diarrheal diseases</li> </ul>	<ul style="list-style-type: none"> <li>National Health Data (EDHS, Welfare Monitoring Survey, housing and population Census</li> </ul>
Outcome	<ul style="list-style-type: none"> <li>Sustainable provision of safe water and improved operational efficiency</li> </ul>	<ul style="list-style-type: none"> <li>Improved water quality and quantity available</li> <li>Improved resilience of water system</li> <li>Consumer satisfaction</li> </ul>	<ul style="list-style-type: none"> <li>Water quality data reports</li> <li>WSP monitoring reports</li> </ul>
Outputs	<ul style="list-style-type: none"> <li>Resilient water supply infrastructures rehabilitated/expanded and increased investments to reduce hazards and risks to water quality</li> <li>Improved risk management and water safety management, operational, financial and planning capacity of the utilities</li> </ul>	<ul style="list-style-type: none"> <li>Long term asset management strategy and financing arrangement</li> <li>Internal and external Quality control and quality assurance system put in place</li> <li>Regular operational monitoring</li> <li>Improved water quality and quantity</li> <li>Increased responsiveness and accountability</li> </ul>	<ul style="list-style-type: none"> <li>Utility and surveillance agency performance reports</li> <li>Customer satisfaction survey reports</li> </ul>
Activities	<ul style="list-style-type: none"> <li>Utility and surveillance body staff knowledge and skill improvement through training programs, including on climate change</li> <li>Standard operation procedures for water supply systems from catchment to point-of-use made available</li> <li>SOP for incidents conditions made available</li> <li>Water supply system asset management information system established</li> <li>Utility Support programs strengthened</li> </ul>	<ul style="list-style-type: none"> <li>Number trained/skilled utility and surveillance workers</li> <li>Necessary SOPs available at all levels</li> <li>Clear /full asset information by place, service year, size, length, capacity, etc documented</li> <li>Number of utilities implementing CR-WSPs</li> <li>Information on staff performance and turnover rate documented</li> <li>Functional Water quality laboratories (utilities and regulators)</li> </ul>	<ul style="list-style-type: none"> <li>Utility and surveillance body monitoring and verification records</li> <li>Monthly, quarterly, and annual performance review reports</li> </ul>

4.4.5. Table 11: Advocacy and awareness creation activities during the preparation phase

SN	Activities	Target audience	Expected outputs	Responsible body
1	<p>Advocacy to policy makers, regulators, meteorological agency, local governments, basin water board/catchment offices, water quality organizations and other stakeholders on the WSP concepts, approaches and its benefits, importance of WSP demonstration as well as on the impacts of climate change (past, current and future) on water supply systems to gain management and operational commitment</p>	<ul style="list-style-type: none"> <li>• National level: Minister/Deputy ministers/directors of water, health, regulatory/members of Parliaments, water board officers, MoHSW, /agriculture /Water Utility Managers; , Regulators and TMA Regional/level: Regional Commissioner, Regional Water Engineer, Catchment officer, Regional health officers, Water utility managers and Board chair persons, District Commissioners, Municipal/District Executive Director, District, Full Council and major WASH sector donor and NGOs</li> <li>• Ward level = Ward Development Committee (WDC) and Community Based Organization (CBO).</li> <li>• (advocacy, awareness creation)</li> </ul>	<ul style="list-style-type: none"> <li>• Creation/establishment of clear understanding on the concepts and benefits of WSP and its linkage with the water resource and health policies among decision makers and senior professionals, and how climate change considerations can be included into the assessment so as to reduce risks (REVIEW OUTPUT ORIENTED)</li> <li>• Gaining leaders acceptance of the approach and approval of implementation of WSP (both demonstration and scale up)</li> <li>• Policy support from national and regional levels down to the local governments (actions required to support WSP implementation at national and regional levels identified) with time frame to monitor Water safety planning processes</li> <li>• Consensus reached on the importance of institutional arrangement at all levels and multi-agency cooperation to support WSP implementation. National, regional/zonal and WSP implementation steering committees and technical working group established and technical support put in place</li> <li>• Sensitization of the operational staff on the WSP approach and its benefits is going on in the WASH sector actors and utilities through leaders and senior staffs</li> </ul>	<p>MoW, MOHSW, MoIT (TBS),</p>
2	<p>WSPs training for Water Utility Staff</p>	<ul style="list-style-type: none"> <li>• Operation and maintenance staff, treatment staff, health regulator and, Water basin Officers,</li> </ul>	<ul style="list-style-type: none"> <li>• Clear understanding on the concepts, benefits and applicability of WSP established</li> <li>• Clear understanding on risks posed by climate</li> </ul>	

SN	Activities	Target audience	Expected outputs	Responsible body
		NGOs <ul style="list-style-type: none"> <li>• Climatologist/Hydrologists</li> </ul>	variability and change to the water system <ul style="list-style-type: none"> <li>• Differences between existing practices and WSP, and environments in which utilities are operating (internal and external stakeholders interactions/influences on the utility) are clearly understood</li> <li>• Ward level WSP implementation support team formed</li> <li>• The Utility WSP implementation team formed</li> <li>• Roles and responsibility of internal and external stakeholders' identified and agreed</li> </ul>	MoW, MOHSW
3	Exposure visits for WSP team/members to other Water Utilities/ other countries with best practices	Minister/ Deputy ministers/ Directors, WSP team/members	<ul style="list-style-type: none"> <li>• Clear understanding on how the strategy and the CR-WSP implementation is led by decision makers and their level of engagement in the process WSP development and implementation, practical experiences gained /exposure on service improvement, etc</li> <li>• Leadership commitment increased and WSP development and WSP implementation facilitated in the regions</li> </ul>	MoW, MOHSW and WHO and other interested partners

As part of the planning phase, it is important to enlist internal and external stakeholders likely to be involved and identify their level of involvement in the development and implementation of WSPs at national, regional, district and utility levels. This process helps for prior identification of the specific roles to be played by the top management and the staff of water, health, regulatory, water basin boards/catchment offices, and the utilities at all levels in general, and at WSP implementation levels in particular.

#### **4.5 FORMATION OF WSP TECHNICAL WORKING GROUP (TWG) MOVE TO M AND E**

At National all five technical working groups (TWG) will be responsible to ensure smooth implementation of WSP. At regional (Regional Water and Sanitation team) and district level, the responsibility lies to regional water and sanitation teams. At ward and village/ MTAA level water and sanitation technical teams will be established. These teams will comprise members from WASH sector organizations mainly composed of water, health, education and community development. These technical working groups will provide technical advisory role to ensure effective implementation of WSPs at each level.

#### **4.6. WSP TEAM REVIEWS**

Water Safety Plan development and implementation is led by the water utility. Formation of the WSP team considers composition of utility managers, professionals from different expertise background on the water supply system design, water quality management and surveillance, basin water officers , environmental health, , and with knowledge of the social sciences and economic dynamics in the population. Therefore, the WSP team includes water supply engineer, surveyor, hydro-geologist, water chemist, and socio-economist from the utility and public health laboratory technologist and environmental health. Drinking water sources vulnerability assessment is conducted at climatic zone level and all urban utilities within the same climatic zone use assessment finding to develop and implement water safety plans. In towns where meteorological stations exist, meteorologists are considered to be a member of WSP team. Whereas, WSP teams of other utilities located within the same climatic zone use local climate and weather information from their respective meteorological station.

Level of responsibility and involvement of the WSP team members could vary depending on the WSP development and implementation steps. Number and mix of team members during WSP step two (system assessment and hazard analysis) might require involvement of majority of the team members to establish baseline (benchmark), some of the team members during operational monitoring and management and communication, etc and therefore, number of professionals to be involved will be determined on the size and complexity of the water supply systems, availability of the skilled professionals, and utility managers' decision and urgency to implement the water safety plan.