WWQA Africa Use Cases

Stakeholder Workshops and Baseline Report for the Volta River Basin

Summary

July 2023

Executive Summary

The selected African Use Cases under the WWQA comprise: Cape Town Main Aquifer Systems; Lake Victoria transboundary lake basin, and the transboundary Volta River basin. This report focusses on the Lake Victoria and Volta Basin Use Cases.

Aim

The Use Cases are funded as a pilot to demonstrate the value added of an Alliance approach to bridge from data to solutions. The central aim in the initial WWQA Africa Use Cases is the integration of in-situ and remote sensing-based Earth Observation and water quality modelling data to derive the best possible current state of water quality combined with a multi-stakeholder driven process defining demand for water quality services. The ultimate objective was to provide an evidence base that links water quality hotspots to solutions and investment priorities. These results emanating from this approach are due to be shared widely with the World Water Quality Alliance partners for further consideration and illustration of the approach.

This report summarises the stakeholder engagement process, data availability, and identification of water quality products and services to address the problems identified through the stakeholder engagement and data assessment process in the Volta Basin. It concludes with summarizing some of the main limitations encountered when trying to access data, and with lessons learned and recommendations regarding the way forward. The full report provides details on these various stages and presents the data collected on water quality and used for the Use Case.

<u>Methodology</u>

Requests for stakeholders and/or data for the Use Cases were sent to relevant working groups carrying out the World Water Quality Assessment as case information. Using the contact details received, these stakeholders identified by the World Water Quality Alliance were then in turn also contacted requesting both data and any additional stakeholders (snowball mechanism), which continued as an iterative process. In addition, a thorough literature review of stakeholders and data was conducted. Through this process, available data (in-situ, modelled, RS/EO) for the Use Cases was collected and shared with the expert teams in charge of the triangle approach in the World Water Quality Assessment (EOMAP, Helmholtz Centre for Environmental Research, and Ruhr University Bochum). In addition, a database of stakeholders and their interest in collaboration was developed, shared with the Alliance community of practice, and enhanced throughout the project. The stakeholder engagement process to identify the key water quality concerns and the need for associated water quality products and services took various forms for the Volta Basin Use Cases. This included:

- Attendance at conferences/symposia in Ghana,
- The convening of a Stakeholder Engagement Workshop in Accra, Ghana with the assistance of the Institute for Environment and Sanitation Studies (IESS) University of Ghana.

Volta Basin

The key water quality challenges identified by the Stakeholder Engagement Workshop participants were: poor sanitation resulting in elevated bacterial contamination, mining activities and heavy metal and turbidity impacts, industrial effluent (including plastics and micro-plastics), agricultural runoff of fertilizers and pesticides, leading to increased aquatic alien plants, and water quality impacts to and from aquaculture.

As a result, it was identified that there is an urgent need to understand land use changes and nutrient loadings to watercourses (including watercourse encroachment by communities along the rivers and reservoirs); a need to monitor the spread of invasive aquatic plants; and an assessment of mining impacts.

Further, there is not a consolidated Ghana government department mandated to water quality monitoring, with this role currently split between the Ghana Environmental Protection Agency (EPA) and Water Resources Commission (WRC), highlighting the institutional challenges to optimal water quality

management in the region. Formal letters were sent to the WRC and Ghana Ministry of Sanitation and Water Resources introducing the concept of the WWQA-UC projects and requesting collaboration.

Discussions towards potential water quality product and services are ongoing, in part due to ongoing development of in-country partnerships and collaboration. The initial products and services being investigated to take forward include:

- The Ghana National Disaster Management Organization (NADMO) proposed an innovative tool that translates poor water quality severity (measured through a water quality index) into poor water quality impact (expressed in terms of vulnerability of affected populations). The water quality index would be derived in collaboration with the WWQA representatives, with initial discussions in this regard undertaken with UFZ.
- University of Fada N'Gourma, Burkina Faso proposed a groundwater quality assessment based on remote sensed data, using the DRASTIC vulnerability mapping method in conjunction with land use data to assess pollution risk (Ouedraogo *et al*., 2016). This is being pursued with the University of Fada N'Gourma, Burkina Faso.

During the Use Case, various lessons were learnt with regards to engagement with Alliance members, the development of stakeholder networks, and suitable data repositories. In addition, important lessons were learnt on how to improve engagement with in-country stakeholders to build collaboration and trust between the Alliance and in-country stakeholders. This improved data sharing and collaborative co-design of the water quality products and services.

Way forward

The Volta Basin use case did not fully succeed in providing a water quality assessment and co-designing and developing products and services relevant to the local stakeholders. As a result, additional efforts are needed to adopt a different approach to the social engagement and co-design process with a view to tackle country-specific challenges via adopting a bottom-up approach. Further involvement of WWQA partners with existing relationships and projects in the Volta Basin is needed to strengthen collaborative efforts between in-country parties, and build on existing projects and data.

A comprehensive network of stakeholders should be developed, focusing on local role players that are active in the sphere of environmental support or education, and cultural groups and individual artists that include environmental aspects into their art and performance as well as popular sports celebrities (e.g. soccer). These stakeholders will then be invited to the upcoming 2023 workshop.

Table of Contents

Chapter	Description	Page

List of Figures

List of Abbreviations

2iE	International Institute for Water and Environmental Engineering
AGDIC	Africa Geospatial Data and Internet Conference
AMCOW	African Ministers Council on Water
ARDC	African Regional Data Cube
BaSIS	Basic Sanitation Information System
CEC	Contaminant of Emerging Concern
CERGIS	Centre for Remote Sensing and Geographic Information Services
CIA	Central Intelligence Agency
CLTS	Community-Led Total Sanitation
CReWAS	Conference on Climate Resilience and Waste Management for Sustainable Development
CRS	Catholic Relief Service
CSIR	Council for Scientific and Industrial Research
ECOWAS	Economic Community of West African States
EOMAP	Earth Observation and Environmental Services
EPA	Environmental Protection Agency
GEMS/Water	Global Environment Monitoring System for Water
GEO	Group on Earth Observation
GIS	Geographical Information System
GLM	General Lake Model
GMet	Ghana Meteorological Agency
HYCOS	Hydrological Cycle Observing System
IESS	Institute for Environmental and Sanitation Studies
IGO	Intergovernmental Organization
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
KNUST	Kwame Nkrumah University of Science and Technology
MoU	Memorandum of Understanding
NBO	Niger Basin Authority
NGO	Non-Governmental Organisation
QA/QC	Quality assurance/quality control
RCMRD	Regional Centre for Mapping of Resources for Development
SDG	Sustainable Development Goals
UENR	University of Energy and Natural Resources
UFDG	Université de Fada N'Gourma
UFR/SVT	Université de Ouagadougou. URF Sciences de la Vie et de la Terre
UFZ	Helmholtz Zentrum für Umweltforschung
UNEP	United Nations Environment Programme
UN RCO	United Nations Resident Coordinator's Office
USGS	United States Geological Survey
VBISS	Volta Basin Information Sharing System
VRA	Volta River Authority
WASCAL	West African Science Service Centre on Climate Change and Adapted Land Use
WRC	Water Resources Commission
WRI	Water Research Institute
WWQA	World Water Quality Alliance

1. INTRODUCTION

1.1. Global Water Quality Assessment

1.1.1. Background

United Nations Environment Programme (UNEP) has global custodianship of data collection for indicators regarding the Sustainable Development Goals (SDG) targets 6.3, 6.5 and 6.6 (all connected to water quality) and received the mandate (UNEP/EA.3/Res.10 Dec 2017) to investigate water quality globally in depth, including and beyond SDG 6.3 into emerging issues, global trends, nexus focus, protection, governance and services.

A preliminary *Snapshot of the World's Water Quality: Towards a Global Assessment* was published in 2016 (UNEP, 2016) revealing the lack of monitoring data particularly in developing countries, rendering the sole reliance on measured data impossible. The full Global Water Quality Assessment (GWQA) thus needs to employ a data fusion approach combining in-situ monitoring, modelling and remote sensing and is designed to illustrate causal chain cases from drivers to impacts.

The major components of the Global Water Quality Assessment are:

1) Baseline Assessment of worldwide water quality in surface and groundwater bodies,
2) Scenario Analysis of future pathways of water quality in the freshwater system and its compartments, and
3) Mitigation Options, i.e. information on how to protect or restore water quality.

The ambition of the Global Water Quality Assessment is to work at different scales:

1) The global scale to provide a consistent context regarding the state of water quality and to identify the water bodies being at risk;
2) The water body to river basin scale with the engagement of stakeholders to inform the implementation of the 2030 Agenda for Sustainable Development at relevant scales.

Following UNEA Resolution 3/10 on "Addressing water pollution to protect and restore water-related ecosystems" and building upon the report "A Snapshot of the World's Water Quality" (UNEP, 2016), the United Nations Environment Programme is cooperating with relevant organizations in the World Water Quality Alliance (WWQA, in the following also referred to as "Alliance", see below) to develop a Global Water Quality Assessment (GWQA) for consideration by UNEA 6 in 2023 (see **Figure 1-1**).

Where relevant and applicable, the GWQA will draw upon UNEP's recent work on harmonizing environmental assessments and the management of freshwater ecosystems, namely the Guidelines for Conducting Integrated Environmental Assessments as well as the Framework for Freshwater Ecosystem Management (FFEM). It also builds on related activities of the Global Environment Monitoring System for Water (GEMS/Water) to enhance the capacity to collect and share water quality monitoring data and of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) and its Global Wastewater Initiative (GW2I) and the Global Partnership on Nutrient Management (GPNM).

The World Water Quality Alliance (WWQA) was convened by UNEP as a voluntary and flexible global multi-stakeholder platform representing experts, practitioners and policy networks with the central aim to support delivery of the World Water Quality Assessment ('the Assessment') following the mandate from UNEA Resolution 3/10. As part of the delivery of this mandate, the WWQA will focus on generating and testing a data fusion approach combining different sources of water quality data contributing to the Assessment; horizon scanning, agenda setting and investigating selected priority topics to identify persistent or emerging water quality issues of key environmental and socio-economic concern; and co-designing and operationalizing water quality related services and products, based on a moderated in-country stakeholder driven process.

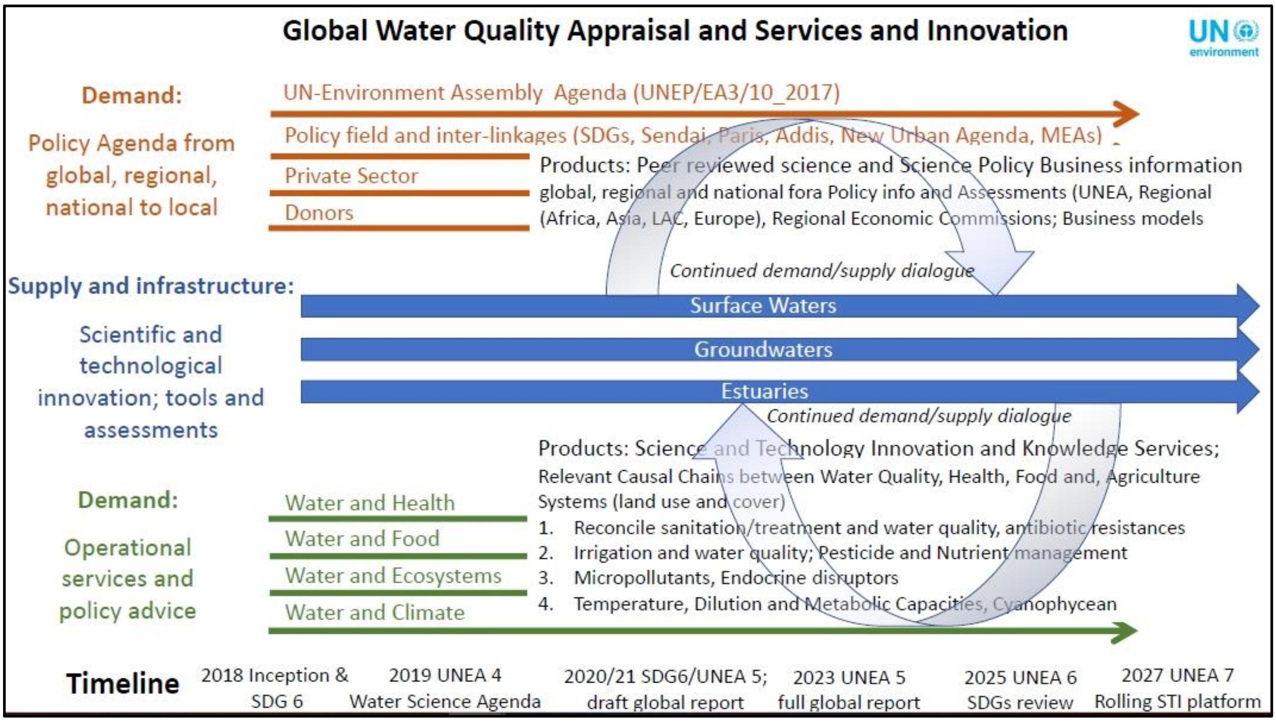

Figure 1-1: Processes and Aspects of Global Water Quality Assessment (Kremer, 2018)

1.1.2. World Water Quality Alliance

To kick off the development of the assessment, UNEP, with support from the World Meteorological Organization (WMO), organized an inception workshop in November 2018. During the workshop, UNEP convened around 50 organizations (UN, research, civil society, private sector), which had expressed interest to engage in the assessment and to also work with UNEP in co-designing agendas and action around emerging issues. This process with strong support from donors marks the emergence of a World Water Quality Alliance as an open community of practice. UNEP, and more specifically the Global Environment Monitoring Unit in Science Division, fulfils the coordination function of the Alliance, through the WWQA Coordination Team.

The World Water Quality Alliance (WWQA) represents a voluntary and flexible global multi-stakeholders network that advocates the central role of freshwater quality in achieving prosperity and sustainability; it explores and communicates water quality risks in global regional, national and local contexts and points towards solutions for maintaining and restoring ecosystem and human health and well-being with an aim to serve countries throughout the lifetime of the 2030 Agenda for Sustainable Development and beyond.

The Alliance focuses on deliverables on three levels:

a. A global assessment of freshwater quality drawing on science – technology – innovation, including a data fusion approach combining in-situ monitoring, modelling and remote sensing. It will expand to additional sources and illustrate causal chain cases to highlight water quality risks and opportunities

b. Horizon scanning, agenda setting and investigating selected priority topics based on a collective prioritization process to identify persistent or emerging water quality issues of key environmental and socio-economic concern and,

c. Following a bottom up-approach, co-designing and operationalization of water quality related services and products, based on a moderated in-country stakeholder driven bottom-up process to identify local demands and needs.

The Alliance was officially launched at the 2nd global meeting at the Joint Research Centre (JRC) of the European Commission in Ispra, Italy on 19 September 2019.

> ***Mission Statement of World Water Quality Alliance:***
>
> *The World Water Quality Alliance (WWQA) forms an open, global consortium, pooling expertise on water quality science and technology innovation. It aims at providing a participatory platform for water quality assessments and co-design of tailored and demand-driven services. It addresses priority topics relevant to water governance, scalable water solutions and emerging issues in water management.*

1.2. WWQA – African Use Cases

During the WWQA Inception Workshop held in November 2018 in Geneva, the Alliance decided to pilot and demonstrate current capabilities and future water quality information services through three case studies in Africa (in the following referred to as Use Cases). These Use Cases provide an initial testbed that puts the quality of surface and ground waters into the context of the local 2030 Agenda and its multiple linkages across the Sustainable Development Goals (SDG). Central in these initial test cases will be the integration of in-situ and remote sensing-based Earth Observation and water quality modelling data to derive the best possible current state of water quality (baseline) with a multi-stakeholder driven process defining demand for water quality services. The ultimate objective is to provide an evidence base that links water quality hotspots to solutions and investment priorities. The results produced by the Use Cases in this two-pronged approach are meant to be shared widely with the World Water Quality Alliance for further consideration.

The Use Cases are funded as a pilot to demonstrate the value added of an Alliance approach to bridge from data to solutions. The Africa Use Case process comprised transdisciplinary engagement with in-country partners through a bottom-up approach aimed at using experience in global problems to support local solutions.They combine data assimilation with transdisciplinary engagement and joint design of water quality products for operational use. Integral to the projects is a moderated, in-country, stakeholder-driven process to identify and address local needs (local solutions to global problems). The co benefit for the assessment originates in the decision to align the Use Case approach to the selection of case studies of the assessment and follow the triangulation approach (see below). In addition, and - different from the assessment - the Use Cases also test out the on-ground stakeholder engagement process towards piloting and testing co-designed products to address key water quality issues.

1.2.1. Objectives

The project aims are expanded upon within the UNEP/WWQA case studies work package draft:

- *Build the “use case” for a Global Water Quality Assessment by means of the piloting and demonstration of current capabilities, future information and services of the World Water Quality Alliance (the “Alliance”) through these three (and other potential) case studies.*
- *Proof of concept for the WWQA to contribute into the innovation data assimilation platform from different available sources (in-situ, modelling and EO). This work will feed into a broader project under development providing a global water quality baseline, and several more pilots globally that aim to look into causal chain relations and solutions along nexus interactions.*
- *Provide an evidence base that links water quality hotspots to solutions and investment priorities. Crucial is a multi-stakeholder in-country driven process defining demand for water quality services, with potential stakeholders including government, academia, civil society and (inter)national organisations.*

1.2.2. Selection

Based on the objective and aim for use cases and the identified criteria, the participants of the 1st WWQA Workshop in Geneva on 28-29 November 2018 selected three Africa Use Cases comprising different water quality challenges, existing data and information, governance aspects and hydrological conditions.

African Use Cases were selected, as meeting the water challenge in Africa requires the availability of a sufficient quantity and quality of water for health, economic activities, human well-being and ecosystems, while resisting hydrological extremes. Several national, regional and global trends however pose substantial risk:

- Rising water needs and usage by the extension of agricultural irrigation,
- Expansion of industry and mining activities,
- Rapid urbanization: African cities among the fastest growing in the world,
- Expanding extraction of raw materials, with effects on water quantity and quality.

Climate change and mismanagement of water resources increase the risk of water scarcity resulting in changing amount and distribution of water regionally. Deterioration of ambient water quality and of aquatic ecosystems can be attributed to lack of infrastructure for urban and industrial wastewater treatment and increasingly improper use of fertilizers and pesticides in agriculture. Safe drinking water and sanitation is particularly low in rural areas and informal urban settlements in Sub-Saharan Africa with negative consequences for education, health and economic development. The extent of aquatic ecosystems and thus ecosystem resilience is increasingly limited by competing land use affecting river corridors, flow regulation for irrigation, and power generation.

The selected African Use Cases comprise:

- Volta River Basin: Transboundary river basin, shared between Burkina Faso, Togo, Mali, Cote D'Ivoire and Ghana; main water quality issue are pathogens
- Lake Victoria: Transboundary lake, shared between Kenya, Tanzania, Uganda, Rwanda and Burundi; main water quality issue is impact on ecosystem health
- Cape Town Main Aquifer Systems: Variety of aquifer systems in and around Cape Town; earmarked for water supply to Cape Town; water quality issues are pollution due to land use activities, geogenic elevated concentrations, impact on surface ecosystems

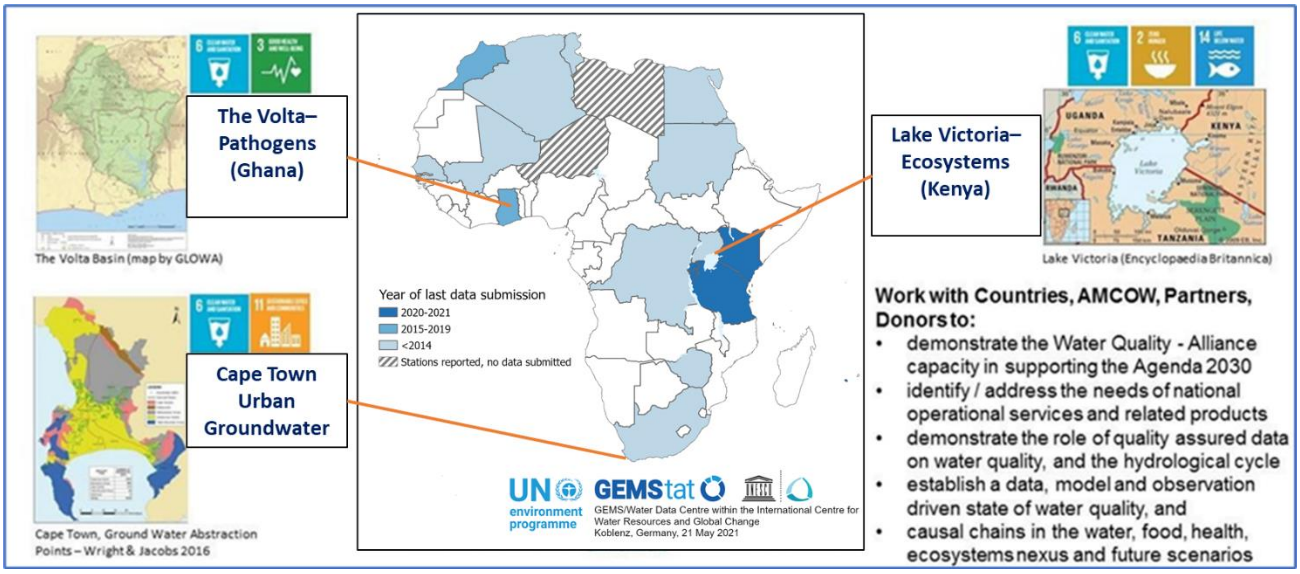

Figure 1-2: Selection of the three African Use Cases (Kremer, 2018)

1.2.3. General Study Process

The use cases followed a three-phase approach, which included an assessment of data availability, stakeholder engagement, a water quality assessment through a combination in-situ data analysis, earth observation (EO) data and modelling, and final reporting. The process was stakeholder focussed so that products and solutions could be co-designed and co-created between the WWQA partners and the local stakeholders (see **Figure 1.3**).

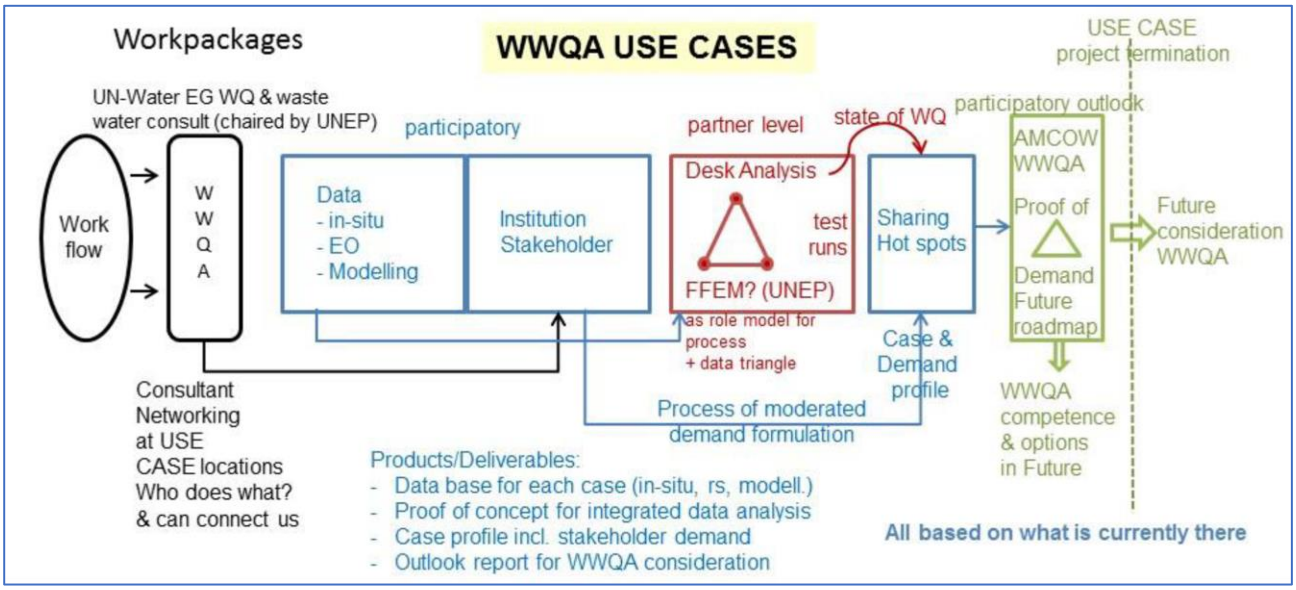

Figure 1-3: Process and Work Packages of Use Cases (Kremer, 2018)

1.3. VOLTA RIVER BASIN

This section provides a summary of the literature review on the Volta Basin water quality challenges, outcomes of the stakeholder identification process, a summary of data availability associated with water quality, a summary of the stakeholder engagements, the identification of water quality products and services to potentially take forward to co-design between WWQA representatives and in-country partners.

The study area will focus on the basin contributing to Lake Volta within Ghana. However, where possible, this will be expanded to include the other contributing countries - in order of contributions: Burkina Faso (43%), Togo (6%), Benin (4%), Mali (4%), Côte d'Ivoire (3%) - with the remainder of the basin being within Ghana (40%). The Volta Basin Data was obtained from the United States Geological Survey (USGS) HydroSheds[1] website.

1.4. Report Aims and Objectives

The aim of this report is to summarize the outcome of Phase 1 of the Africa Use Case and the proposed scope for Phase 2.

[1] https://hydrosheds.cr.usgs.gov/

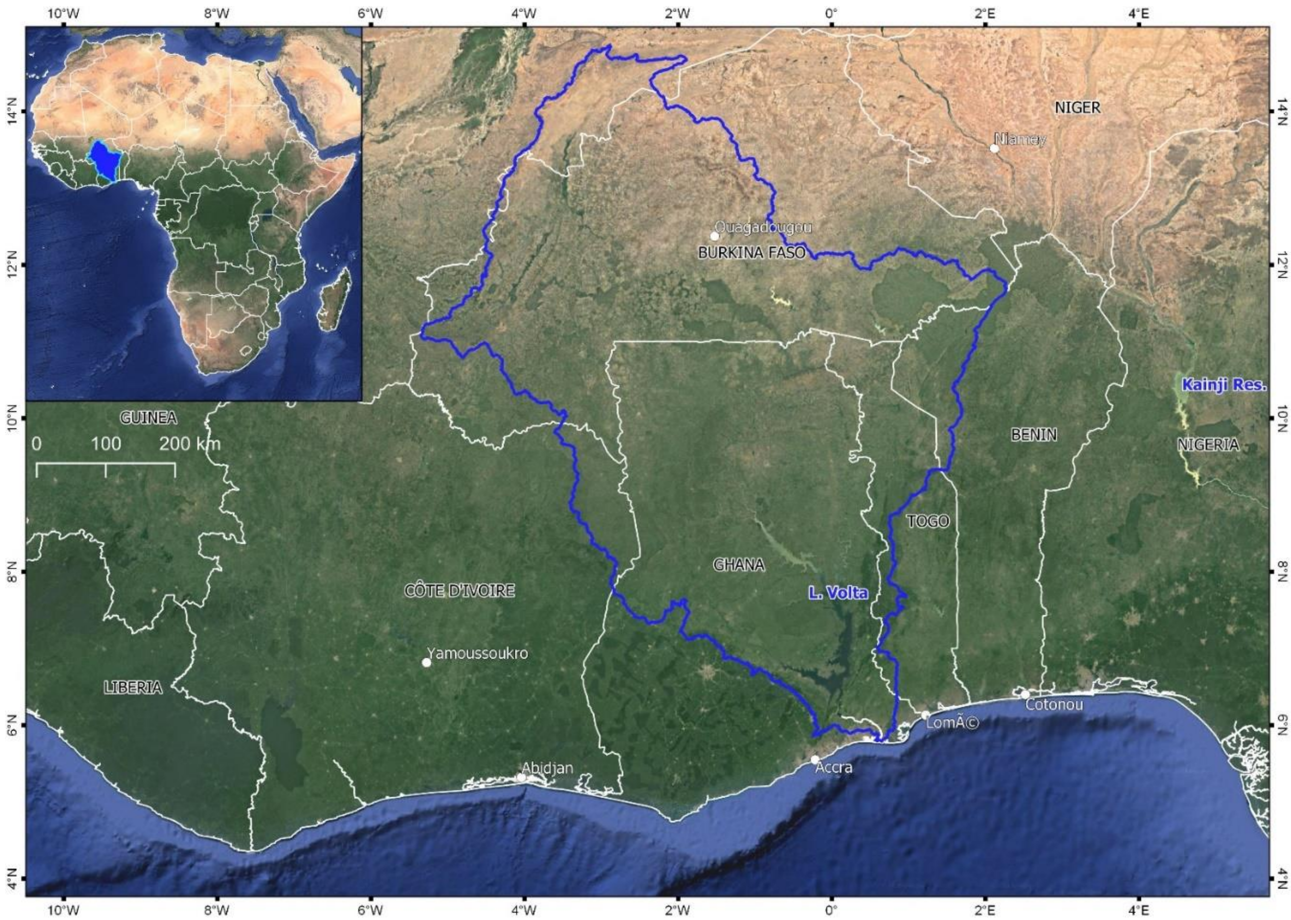

Figure 1.4 Volta Basin Use Case Study Area

2. Stakeholder engagement

Requests for stakeholders and/or data for the Use Cases were sent to WWQA members. Using the contact details received, these stakeholders identified by WWQA members were then in turn also contacted requesting both data and any additional stakeholders, which continued as an iterative process. In addition, a thorough literature review of stakeholders and data was conducted. Through this process, available data (in-situ, modelled, RS/EO) for the Use Cases was collected and shared with the WWQA triangle partners (EOMAP, Helmholtz Centre for Environmental Research, and Ruhr University Bochum). In addition, a database of stakeholders and their interest in collaboration was developed, shared between WWQA members, and enhanced throughout the project.

2.1. Initial stakeholder engagement

Stakeholders identified through feedback from the WWQA, as well as through the stakeholder engagement process (both online and in-country) are summarized in **Appendix A**. The key in-country stakeholder engagement undertaken is summarized below.

2.1.1. Conference on Climate Resilience and Waste Management for Sustainable Development (CReWAS), Accra, Ghana

The Conference on Climate Resilience and Waste Management for Sustainable Development (CReWAS) was organized by the University of Ghana Institute for Environment and Sanitation Studies (IESS), in collaboration with Worldwide Universities Network (WUN) on 16 – 17 October 2019 at the University of Ghana in Accra.

Key outcomes where an improved understanding of the water quality challenges in the Volta River Basin, especially related to solid and liquid waste management in Ghana.

Potential solutions to the solid and liquid waste impacts discussed included better adoption of a circular economy, better waste handling (e.g. segregation), improved solid waste recycling/re-use and associated education and incentives, improved local traditional knowledge and practices, as well as better government support towards waste collection and recycling.

2.1.2. Africa Geospatial Data and Internet Conference (AGDIC), Accra, Ghana

The Africa Geospatial Data and Internet Conference (AGDIC) was held in Accra, Ghana, from 22 – 24 October 2019. Below are the key observations made.

The Ghana Water Company presented on urban water supply, including automatic water quality monitoring at the production sites, stating that the water meets WHO standards. However, there is a high use of bottled and sachet water in Accra due to concerns of reticulated water quality, leading to a high level of plastic waste generated, although sachet water often comprises un-treated tap water.

The Ghana Ministry of Sanitation and Water Resources presented on sanitation, with mention of BaSIS (Basic Sanitation Information System). This is a decentralized monitoring and evaluation sanitation system developed to aid in the implementation of the Community-Led Total Sanitation (CLTS) at both sub-national and national levels in Ghana. The system is built to populate data collected from approved sources based on some sanitation index in the form of maps, charts and tables.

2.2. Stakeholder Workshop in Accra, Ghana

An Expert Consultation Workshop was organised to take place in Accra, Ghana from 25-27 February

2020. The objective of the workshop was to initiate a long-term collaborative network of stakeholders and WWQA members associated with the water quality of the Volta Basin that work to define in-country water quality hotspots and solutions.

Workshop logistics were arranged by UNEP, with the help of the Institute for Environment and Sanitation Studies (IESS) at the University of Ghana. The institute is well respected in the region for their research on water resources, including water quality. As a result, their involvement was critical in promoting collaboration on the Africa Use Case concept in the region.

The workshop took place at the Tomreik Hotel, Accra, Ghana from 25-27 February 2020. The Agenda is provided in **Appendix C**. Attendees included representatives from government and academia in Ghana and Burkino Faso, NGO/IGOs, and project partners (GEMS/Water and UFZ). The majority of attendees is captured in **Figure 2-1**.

Figure 2-1: Workshop Delegate Photograph (Day 1)

2.2.1. Objectives

The objectives of the workshop were outlined as follows:

- **Objective 1**: Enhanced understanding of the African Use Case concept. **Outcome:** An understanding of the importance and benefits of the African Use Cases, particularly Volta Basin and how the WWQA can assist
- **Objective 2**: Discuss Volta Basin water quality concerns. **Outcome:** Improved understanding of the water quality hotspots in the Volta Basin
- **Objective 3**: Determine the key water quality datasets available and any limitations to data sharing. **Outcome:** Begin process to enhance data sharing between stakeholders.
- **Objective 4**: Discuss research and information gaps in the Volta Basin. **Outcome:** Begin discussions on water quality data and information products and services to be co-developed to target hotspots.
- **Objective 5**: Initiate a bottom-up social engagement process between in-country

stakeholders and WWQA **Outcome:** Supporting local solutions through global experience.

The following aspects were discussed during the workshop. These are detailed in the **Appendix D**.

- Water Quality Concerns (see below and Section 3)
- Issues that need more research and information for more informed decisions
- User groups that would benefit from better data availability
- Volta Basin Water Quality Data Holders and Providers
- Data Repositories
- Limitations to Sharing Water Quality Data
- Challenges for effective research and implementation
- Opportunities for effective research and implementation
- Identification of Participant Water Quality Requirements
- Best forum to discuss possible products/services (see below)
- Additional role-players to be included going forward

2.2.2. Workshop Outcomes

A panel discussion was held to workshop the water quality concerns In the Volta River Basin. To guide the session, the discussions included the interaction of water quality with Health/Cities, food and ecosystems. The discussion was facilitated by Prof. Christopher Gordon of the IESS, University of Ghana. The Panel comprised representatives from the following organisations and institutions:

- Ghana Council for Scientific and Industrial Research (CSIR) Water Research Institute (WRI)
- Water Resources Commission of Ghana
- Volta River Authority
- Ghana Community Water and Sanitation Agency
- Burkino Faso Directorate General of Water Resources
- University of Fada N'Gourma

The Africa Use Case concept includes a process of consultation between Use Case stakeholders and Alliance members to co-design the water quality data and information product(s). As a result, the workshop included a session to agree on the best forum to undertake these discussions.

It was agreed by participants that this forum should be chaired by WRC under the supervision of the Executive Director. It was agreed that this would be formally communicated by UNEP. Thereafter, WRC would invite key organisations for collaboration.

The platform that would provide the most efficient form of communication was discussed, and it was agreed that this should be in the form of email and once the collaborative group is finalised, to include communication via a more informal mobile platform such as WhatsApp.

3. Water Quality Issues

3.1. Current water quality challenges

3.1.1. Poor sanitation

Untreated sewage is discharged directly into the environment in larger cities such as Ouagadougou, Bobo Dioulasso, and Abidjan. In Ghana, national assessments identified 70 decentralised wastewater and faecal sludge treatment plants serving less than 10% of the urban wastewater volume, and of these, only 13% were still operating (UNEP, 2016).

This problem is exacerbated by extensive livestock production, which is a major economic activity in various parts of the basin. This results in bacteriological contamination in the watercourses (Abdul-Razak, 2009; Samah, 2012) increasing the risk of acquiring decreases such as diarrhoea. Waterborne diseases are a threat to the rural communities, with a significant contribution to the 2012 mortality rates of children aged less than 5 years in Benin (10%), Burkina Faso (11%), Ghana (7%), Côte d’Ivoire (10%), Mali (12%), and Togo (9%) (UNEP, 2016).

The faecal contamination of water in the Volta basin has important implications for urban and rural water supply. The Volta Lake, for example, is a water reservoir for large cities such as Akosombo; and rural communities depend directly on the surface water as they tend to have less access than urban communities to potable water from boreholes, pumps, or piped water taps. Burkina Faso and Ghana have a largely rural population. As a result, only 37% (in Burkina Faso) to 62% (Ghana) of households have access to safe drinking water. Even where there is access, many still prefer and continue to use untreated water from the river due to quality perceptions and opportunity costs (UNEP, 2016).

Faecal coliform levels are consistently above WHO guidelines for drinking water with levels in the Asukawkaw River for March-June 2012 contributing about 40 % to the total volume of the Volta Lake. In Mali and Burkina Faso, surface water quality is poor with numerous coliform and bacillus bacteria. Further, in the Sourou Valley in north Burkino Faso shallow wells that are a preferred source of drinking water are highly polluted with coliforms (UNEP, 2016).

Contaminated water also has implications for aquatic organisms such as clams, a common and inexpensive source of protein and livelihood for the communities at the Volta estuary. This is due to a clam’s capacity to accumulate up to five times the bacterial load in the surrounding water, through its filter feeding activities. The evidence of high microbial contamination of fish caught in polluted waters, making it unsafe or undesirable to eat (UNEP, 2016).

The concentration of faecal coliforms can be influenced by seasonal changes, with high contamination levels at the onset of heavy rains where runoff carries raw sewage and leachate from waste dumping sites into the water bodies (UNEP, 2016).

3.1.1.1. Mining

Small scale gold mining in Ghana (locally called ‘galamsey’) has become a major contributor to the economy since its legalization in 1989. However, chemicals, especially mercury, from the mining process impacts surface water resulting in water bodies that were once main sources for drinking water now being heavily polluted (Owusu, 2016).

Gbogbo et al., (2016) reported mercury levels in Volta River Basin waters are higher than the WHO drinking water limit of 0.006ug/ml (World Health Organization, 2005). This results in fish, crustaceans and molluscs with mercury levels exceeding the limit set by the Commission Regulation-European Commission for fishery products, muscle meat of fish, and crustaceans.

3.1.2. Industrial effluent

One of the major sources of pollution in the Volta basin is industrial waste. A survey of manufacturing industries in the Greater Accra Region showed that the metal industry creates 16% of the total industrial waste, garment and textiles 30%, chemicals and cosmetics 20%, electricals and electronics 1% and mineral products 0.7% (Boadi and Kuitunen, 2002). Examples of waste include detergents and other cleaners – which contain phosphorus, thus promoting algal growth; chemicals and compounds from asbestos sludge; dyes, spent fuel from garages, etc.

3.1.3. Agricultural runoff

Farming is one of the main livelihoods within the Volta basin. However, intensive agriculture and the use of pesticides and fertilizers increases these potential pollutants within the Volta basin (Bobobe et al., 2012). High nutrient loads from agricultural sources occur in specific locations such as cotton, sugar cane, or commercial oil palm plantations (UNEP, 2016).

3.1.4. Aquatic Alien Plants

Over the last few decades, pervasive water weeds have been a problem for rivers and lakes within the basin. In Ghana, this is a problem which has also been exacerbated by the building of dams, which lead to a proliferation of weeds in the lakes created from the damming process, as well as the rivers up-stream and downstream of these lakes (Gordon and Amatekpor, 1999).The Black and White Volta Rivers have been reported to be infested by the water hyacinth, which also threatens infestation of the Lake Volta in Ghana.

The weeds negatively impact water transport; hydro-power generation; water flow; crop irrigation; aquatic life and can increase in diseases such as malaria and bilharzia (Aloo et al., 2013)

3.2. Potential future water quality challenges identified

As in many other countries across the globe, climate change has had negative impacts on Ghana, with research showing increased evaporation, decreased and highly variable rainfall pattern, and frequent pronounced flood and drought situations. This rainfall pattern is regarded as the main cause for declining lake levels in the Volta basin above the Akosombo Dam for example (Owusu, 2008).

In a 2009 review paper, Delpha *et al*. discussed the impacts of climate change on surface water quality in relation to drinking water production. Some of the impacts of climate change related temperature increases on water quality parameters discussed were:

- Increases in pH
- Lower dissolved oxygen
- Increase in mineralization and release of nitrogen, carbon and phosphorus from soil
- Increased rate of pollutant uptake due to an increased metabolic rate and decrease in oxygen solubility, etc.

These changes will lead to problems such as the fuelling of phytoplankton growth and subsequent algal blooms and a deterioration in water quality. It has also been shown that micropollutants, dissolved organic matter and pathogens are susceptible to rise because of temperature increases, thus adversely affecting the quality of drinking water. Rainstorm events will also lead to elevated levels of turbidity and organic matter found in river waters which cause deterioration in treatment performance.

Population increase and urbanization pose a threat to the water resources within the base. Growing demand for water means that supplies will be severely stretched, and pollution problems and environmental degradation are likely to increase. This situation will worsen as the population continues to grow, urbanization increases, standard of living rises, mining becomes widespread and human activities are diversified (Andah et al., 2003).

In the White Volta Basin, many farmers are converting their croplands (especially yam) to cassava production. Although these kinds of landscape changes are unavoidable due to population increases and industrialization, they will affect the hydrology and water quality in a watershed. This is because the types of ground cover and surface debris, evapotranspiration, infiltration, erosion, and sedimentation will be changed, thereby affecting not only the total quantities of pollutant loads but also the transport pathways of pollutant inputs (Awotwi et al., 2016).

3.3. Summary

The water quality concerns raised at the stakeholder engagement are summarised below:

- There is still a reliance on open defecation in Ghana. This results in elevated bacteriological loads to watercourses. Further, in both Burkina Faso and Ghana it was noted that there was impacts to water quality from bacteria due to sewage contributions to watercourses from insufficient or lacking formal sewage systems.
- There are geogenic sources of elevated iron, manganese, arsenic and fluoride (towards the north of the basin) in the environment.
- There is a reliance of the Ghana Community Water and Sanitation Agency on the treatment of groundwater for potable use. Where groundwater is of non-potable quality, they cap boreholes. However, there are options to treat impacts (e.g. elevated iron and manganese) without ceasing well use.
- Water is sometimes stored in open containers at households, leading to water contamination and health impacts.
- Salinisation and salt-water intrusion in coastal zones and in the drier northern portions of the basin.
- Desalination is used in some coastal areas, with it noted that boron levels can be elevated.
- There is a movement of communities into the watercourse buffer zones in Ghana. This includes communities living below the high-water mark of the Volta Dam. This leads to water quality impacts during high-flow periods (e.g. open defecation leading to elevated bacteriological loads). This is compounded by climate change (reduced rainfall) and watercourse siltation.
- Water-side markets were noted to have elevated microbial pollution. In addition, runoff of fish waste leads to decomposition and anoxia. This is especially prevalent in Lake Volta.
- Plastics and micro-plastics, especially in the lower Volta basin.
- Agriculture, leading to nutrification of watercourses through over-fertilisation. This includes farms within river floodplains.
- Burkina Faso noted water quality impacts from tanneries in operation.
- There is an increase in water hyacinth in watercourses which impacts water quality (e.g. decomposition) and aquatic health. There is a need to monitor the spread of invasive aquatic plants.
- Various water quality impacts were noted as a result of informal (galamsey) and formal mining. This includes elevated levels of cyanide, mercury, lead, arsenic. Mining also was noted to result in acid mine drainage, with groundwater and surface water impacts. Surface water impacts such as turbidity due to sand winning.
- There are impacts to water quality from aquaculture, including from over-feeding and from feed containing antibiotics; having impacts to wild fish. In addition, there are impacts to aquaculture from poor water quality. It was noted that improved understanding on eco-toxicity impacts is required.

4. Data availability

This section outlines the data that has been identified to data for the Volta Basin. This includes data identified via a literature review, as well as through engagement with the Alliance members and in-country stakeholders.

4.1. In-situ measurements

A 2007 study by Quansah *et al.* applied GIS techniques to map in situ water quality data from the Lower Volta. The collected samples were analysed for temperature, pH, conductivity, turbidity, hardness, total dissolved solids, nitrate, ammonia, phosphates, iron and faecal coliforms. These were digitally mapped to show spatial variability of water quality along the sampling locations.

The Institute for Environmental and Sanitation Studies (IESS) at the University of Ghana has undertaken various studies within the Volta Basin. Information is available for transboundary environmental, governance and climate change issues in the Volta Basin. In addition, data is available for:

- Nutrient loading of the sediment and water column in the lower Volta;
- Land-use impacts on water quality in the Volta Basin;
- Environmental quality for aquaculture production, including nutrient inputs, nano-level concentrations of harmful substances such as bacteria, biocides and antimicrobials in sediment, water column and effluent samples.

The GLOWA Volta Project was aimed to develop a framework for water resources decision-making and scientific capacity building in a transnational West African Basin (Van de Giesen et al., 2007). The collection of data associated with the GLOWA Volta Project included climatic, hydrologic, environmental and socioeconomic data, which are scarce within the Volta Basin. Focused studies, many conducted by Ph.D. trainees from the Volta region, attempted to bridge gaps in spatial and temporal scales as solutions to the problems of data scarcity.

The NASA GLOBE[2] program serves as a potential source of useful citizen science data.

4.2. Water quality modelling

Limited water quality modelling data is available across the Volta basin. Awotwi et al., 2016 published a study on the water quality changes associated with Cassava production in the White Volta basin using an interface between ArcGIS and SWAT (soil and water analysis tool). The tool was used to assess the likely hydrologic and water-quality response of increasing cassava production, with reference to nutrient (total nitrogen, total phosphorus) and sediment levels.

Phase II of the GLOWA Volta Project focused on modelling activities. Mesoscale climate models were successfully linked with physical hydrology models (WaSIM-ETH) at catchment, tributary and full basin scales. Numerous anthropologic and socioeconomic studies were successfully completed, creating databases from which a range of household models of socioeconomic behaviour were identified (Van de Giesen et al., 2007).

4.3. Earth observation/remote sensing data

Ghansah et al., 2016 mapped the spatial changes in Lake Volta using a remote sensing approach. The authors looked at Landsat imagery of the lake for the years 1990, 2000 and 2002, which showed that the area of the lake increased from 1990 to 2000 and decreased from 2000 to 2002. The authors also suggest that this method can be used to demarcate buffer zones around the lake, which would be useful to minimize the influx of solid waste into the lake, as well as maintaining its water quality.

[2] https://www.globe.gov/

The ARDC is a tool that harnesses the latest EO data and satellite technology to help various countries, including Ghana, address various issues relating to agriculture, food security, deforestation, urbanization, water access, and more. However, they would benefit from in-situ datasets to validate EO data, including the NASA Ocean Colour Chlorophyll-A OC3 Algorithm for Lake Volta (Ghana) and Weija Reservoir (Accra).

SERVIR Global has the SERVIR Global Service Catalogue, a searchable collection of demand-driven geospatial services that use Earth observations to support decision making and resilient development, including in Water and Water Related Disasters. This includes the monitoring of galamsay activities in Ghana, with information on the location of illegal mining sites across Ghana and their associated land degradation.

Lake Volta has been included int the CGLOPS Data set, with time series and maps available for chlorophyll-a and total suspended matter (TSM). However, it needs some data handling to get the information out of the global products to perform analyses for individual lakes.

EOMAP can share UNESCO world water quality data[3] over Africa. In addition, EOMAP can share the eoLytics tool which enables countries / organizations to produce for water quality monitoring with selectable time frame, resolution, frequency. Further, EOMAP has other earth observation water quality data as well online and free on other portals which can be shared including two web applications with free data available[45]

GEO AquaWatch is building a global WQ monitoring service, merging in situ and remote sensed data that could be integrated.

4.4. Others

IWMI and the other CGIAR organizations are currently working on a platform for data sharing (waterdata.iwmi.org) that includes EO, modelled and other spatial and non-spatial data sets.

The Basic Sanitation Information System is a decentralised monitoring and evaluation sanitation system developed to aid in the implementation of the Community-Led Total Sanitation (CLTS) at both sub-national and national levels in Ghana. The system is built to populate data collected from approved sources based on some sanitation index in the form of maps, charts and tables.

4.5. Limitations to Data Sharing

Overall at the Volta Basin Use Cases there is a reliance on in-situ measurements that leads to limitations in spatial and temporal resolution of water quality. This is exacerbated by concerns around in-situ data sharing by data owners. As a result, there was a need to use alternative options to use alternative data sources such as RS/EO, modelling and citizen science. In addition, there is a need for improved capacity building, including in data analysis, data management, and data sharing policies.

Limitations to data sharing were discussed with in-country stakeholders, with the following feedback:

- A general lack of funding to adequately assess water quality, with a need for sustainable funding and long-term investment. In-country funding by local government was noted to be lacking, with a need for additional contributions (including international funding).
- A need to improve the impact of research through more effective science-policy interface, and to better communicate the science to policy-makers via impact stories (solving real-world problems for real impact).
- A “north-south” divide where data is provided to funded projects, with limited benefit to in-country data providers.

[3] www.worldwaterquality.org
[4] https://eoapp2.eomap.com/
[5] https://eoapp.eomap.com/

- Past experiences where collaborators requested data who then went on to use the data without citing or acknowledging the data sources. There were also concerns that shared data is used without permissions, impacting planned publications by the data providers.
- Some data providers advised that data cannot be shared without payment, thereby limiting organisations such as GEMStat (The Global Freshwater Quality Database, part of the UNEP GEMS/water programme[6]); obtaining data.
- There is a lack of data sharing policies/protocols, with these sometimes being specific to the country or organisation/institution or limited by clauses in donor-funded projects.
- There is a general lack of internal databases to store data in an easily accessible format, exacerbated when databases are shared between organisations/ institutions/ countries. This includes limitations in the availability of hardware, and training on software. Due to a lack of standard formats, there can be data structuring and formatting problems. As a result, there was a consensus that there is need to agree at the start of a project/initiative on a common data-management system, with agreed data types and formats that allows for better collaboration between organisations/ institutions/ countries. It was noted that there is a need for enhanced data sharing via a central validated repository; however, it was noted that this is currently not incentivised, and that this would need long-term funding to collect and make data available to the database.
- While databases where developed with useful data, these were noted to be specific to a project with maintenance stopping after the project ended; thereby resulting in a loss of access to data by stakeholders.
- Fragmented institutional landscape in Ghana regarding water resource management and utilization with responsibility for monitoring, enforcement, resource development split across several national and regional institutions,
- Different institutional landscape and governance structures in neighboring countries with the Volta Basin Authority as transboundary agency apparently not fully functional,
- Lack of involvement of civil society in terms of NGOs, although the Ghanaian Coalition of NGOs in Water and Sanitation was invited, no NGO attended the expert workshop.

[6] https://gemstat.org/

5. Water Quality Products and Services

To assess the Volta water quality challenges and associated impacts, and to assess data sources and types and any limitations to the sharing of such data there was attendance by WWQA members at various conferences in Ghana. In addition, a Stakeholder Engagement Workshop was held in Accra, Ghana to assess the key water quality hotspots and water quality data and information products and services that may be of interest; and the to initiate a bottom-up social engagement process.

The key water quality challenges identified by the Stakeholder Engagement Workshop participants were:

- Poor sanitation (resulting in elevated bacterial contamination, exacerbated in Ghana by community movement into watercourse buffer zones);
- Mining activities (causing heavy metal and turbidity impacts);
- Industrial effluent (variable impacts, including plastics and micro-plastics);
- Agricultural runoff (elevated nutrients and pesticides, leading to increased aquatic alien plants);
- Aquaculture (including impacts to water quality and impacts from poor water quality; and,
- The future challenges identified included climate change, population increase, urbanization, and land use change.

As a result, it was identified that there is an urgent need to understand land use changes and nutrient loadings to watercourses (including watercourse encroachment by communities along the rivers and reservoirs); a need to monitor the spread of invasive aquatic plants; and an assessment of mining impacts.

Further, there is not a consolidated Ghana government department mandated to water quality monitoring, with this role currently split between the Ghana Environmental Protection Agency (EPA) and Water Resources Commission (WRC), highlighting the institutional challenges to optimal water quality management in the region. Formal letters were sent to the WRC and Ghana Ministry of Sanitation and Water Resources introducing the concept of the WWQA-UC projects and requesting collaboration. This included a request for:

- Sharing information on existing water quality databases relevant to the Volta Basin region.
- Assistance identifying and facilitating collaboration of key stakeholders associated with the Volta Basin region.
- A request for collaboration in the development of water quality pilot products and services for local/national application.

All in-country stakeholders identified and shared by Alliance members, as well as those identified through engagement at conferences, workshops and meetings were formally approached via e-mail. The mail included a 1-pager (**Annex B**) specific to the Use Case prepared by Andrew Gemmell, outlining the WWQA, the Africa Use Cases, water quality challenges per Use Case, and the work plan. The objective of this communication was to find out how partners are able to contribute (i.e. existing data, projects and relevant stakeholders in these regions) and would like to see certain aspects of their work featured in these use cases.

Discussions towards potential water quality product and services are ongoing, in part due to ongoing development of in-country partnerships and collaboration. The potential water quality product and services are a poor water quality impact index, and remote-sensed groundwater quality assessment. These are summarised in the following two sections.

5.1. Ghana Water Quality Impact

The Ghana National Disaster Management Organization (NADMO) proposed an innovative tool that translates poor water quality severity (measured through a water quality index) into poor water quality impact (expressed in terms of vulnerability of affected populations). The water quality index would be derived in collaboration with the WWQA. The vulnerability profiling would include the Volta Basin baseline household survey (which includes data on households' water sources and poverty status, as well as population data and administrative boundaries). As the data/model fusion monitors and analyse water quality in the Volta Basin in near-real time, poor water quality will be translated into impact estimates on vulnerable populations (Figure 5-1). Required data for vulnerability profiling include:

- Most recent baseline household survey (Volta Basin coverage);
- With data on households' water sources (for drinking etc.);
- With information on each household's poverty status;
- Representative at sub-national level (ideally Admin 2);
- Population data at subnational level;
- Map files corresponding to the level at which the survey is representative (administrative boundaries).

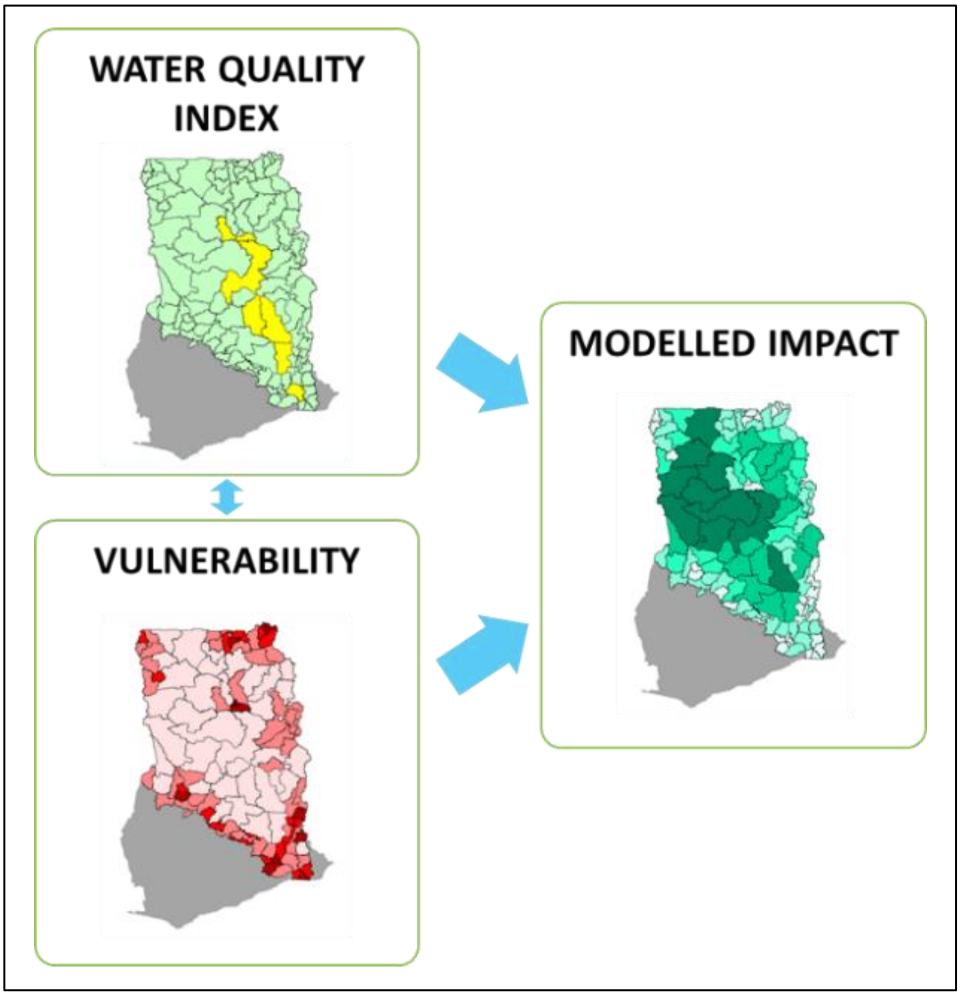

Figure 5-1: NADMO proposal to use a water quality index and vulnerability to calculate a water quality impact.

As proposed by NADMO, in **Figure 5-2**, each district Vulnerability Profile is determined by calculating the percentage of households in that district that are considered vulnerable to poor water quality. Individual households' water vulnerability is determined based on a combination of two factors: exposure to poor drinking water sources and lack of resilience (poverty).

A range for Water Quality Loss Threshold (WQLT) is defined, (where WQLT corresponds to the threshold loss of water quality at household level (in %) above which households would need assistance to be able to access potable water).

According to NADMO, the proposed Volta Water Risk Tool (V-WiT) will help translate outputs of the innovative data/model fusion approach, proposed by the World Water Quality Alliance, into information decision makers / stakeholders at both local and national level will readily appreciate and act upon.

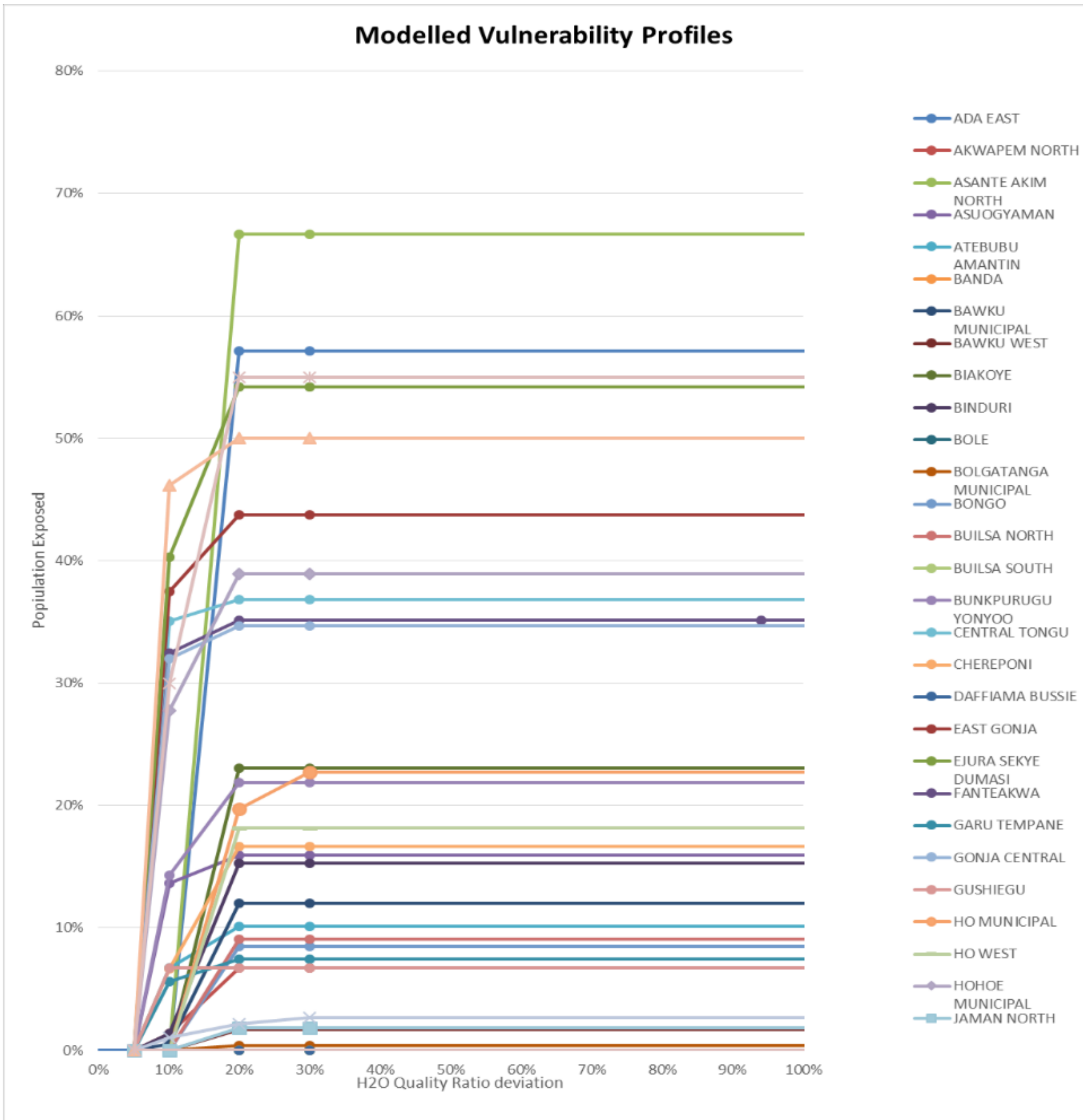

Figure 5-2: NADMO modelled vulnerability profiles determined based on a combination of two factors: exposure to poor drinking water sources and lack of resilience (poverty).

5.2. Remote-sensed groundwater quality assessment

The University of Fada N'Gourma, Burkina Faso has proposed a groundwater quality assessment based on remote sensed data, using the DRASTIC (**D**epth to water, net **R**echarge, **A**quifer media, **S**oil media, **T**opography, **I**mpact of vadose zone, and hydraulic **C**onductivity) vulnerability mapping method in conjunction with land use data to assess pollution risk (Ouedraogo *et al.*, 2016; Honnungar, 2009; Baghapour et al. 2016; Secunda et al. 1998). Each of DRASTIC index parameters is assigned ratings and a numerical weighting to reflect its relative importance in estimating groundwater pollution potential. This is being pursued with the University of Fada N'Gourma, Burkina Faso. A tentative output for the Volta Basin is provided in Figure 5-3.

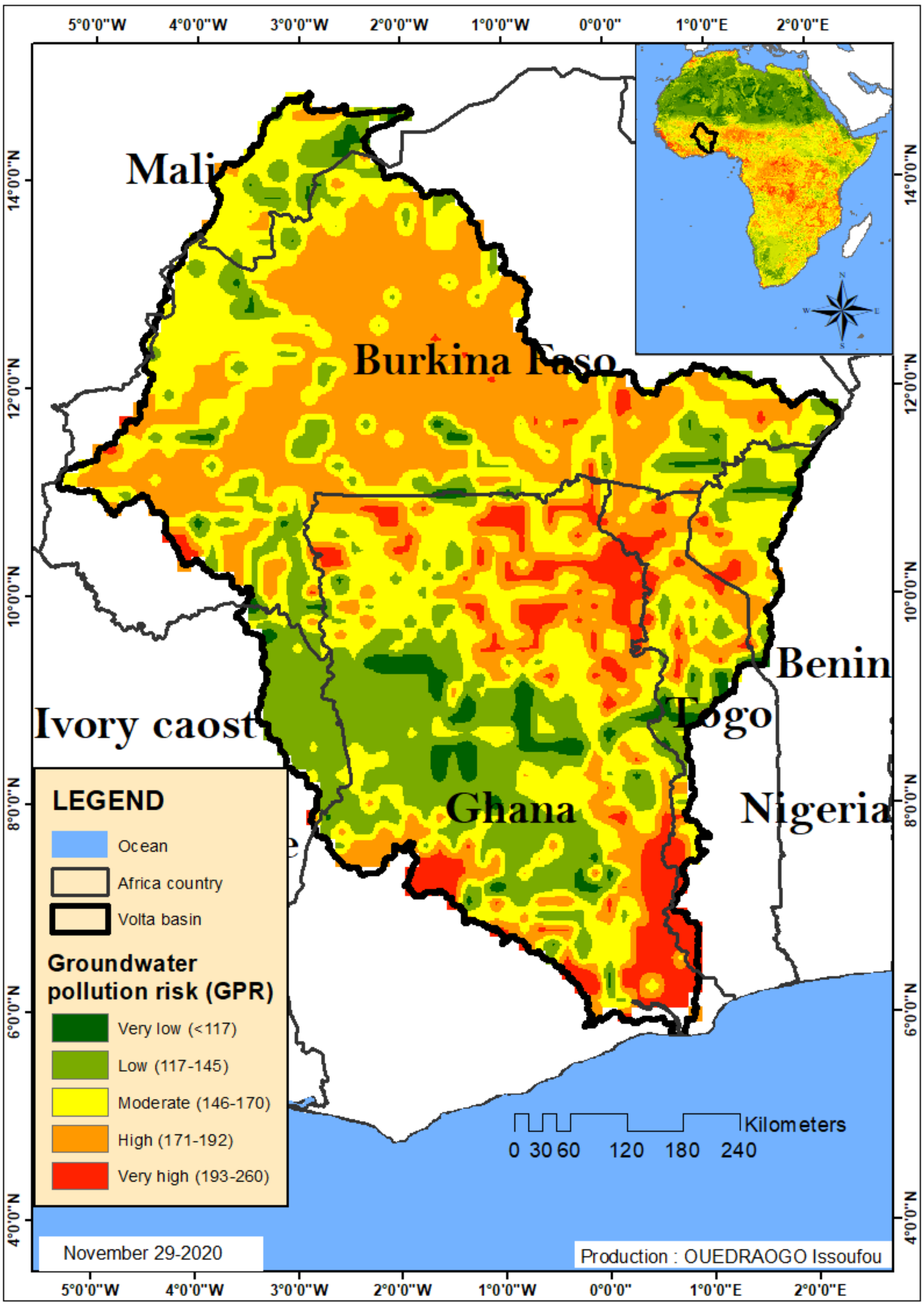

Figure 5-3: Groundwater pollution risk map in Volta Basin area, provided by Issoufou Ouedraogo University of Fada N'Gourma, Burkina Faso

6. Proposed Way Forward

The follow-on project is aimed at addressing the shortcomings identified during Phase 1 by adopting a different approach to the stakeholder engagement and co-design process with a view to tackle country-specific challenges via adopting a bottom-up approach.

Further involvement of WWQA partners with existing relationships and projects in the Volta Basin (e.g. FAO, WMO, World Bank) and other work streams (e.g. Plastics) will strengthen collaborative efforts between in-country parties, and build on existing projects and data. In discussion with the Social Engagement Platform, several approaches for the engagement process will be developed.

It is envisaged to first establish a comprehensive network of stakeholders focusing on a bottom-up and integrated approach, using the principles of the Social Engagement Platform (quadruple / quintuple helix, RENAISSANCE approach to science-culture-sustainability diplomacy, The Council of Citizen Engagement in Sustainable Urban Strategies (ConCensus)). This loose network is not meant to substitute existing structures such as CONIWAS, but to add to these associations, expanding their footprint and strengthening the potential outreach by establishing new connections and possibilities, especially for small, local NGOs. Stakeholders envisioned include:

- Global NGOs, active in the relevant countries and specifically the Volta Basin
- Local NGOs, active in the environmental, waste, sanitation and water sector
- Local NGOs, active in education and citizen science
- Artists, specifically in theater, music and landscaping
- Sport celebrities (retired and active)
- Businesses in the tourism sector
- Businesses in the agricultural sector

Contacts developed during the previous stakeholder identification process, but not pursued during the stakeholder engagement process of the Use Case, will be revitalized for this initial step. Based on the comprehensive stakeholder list and initial one-on-one engagement, the following is planned for this follow-up process:

- In-country workshop(s) to initiate the most promising approach of stakeholder engagement going forward.
- Identification of capacity building needs and development of capacity building plan (to be supported by the Capacity Development Consortium).
- Identification of key institution for stakeholder engagement continuation and development of a funding plan for future implementation

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ANNEX A –STAKEHOLDERS

Volta Workshop Organisation Invitation List

• Adventist Development and Relief Agency, Ghana • AMCOW • BUI Power Authority (Ghana) • Bulk Oil Storage and Transportation Limited (Ghana) • Burkina Faso Ministry of Water, Water Resources and Sanitation. Director of Studies and Information on Water. • Burkino Faso Directorate General of Water Resources, Water Quality Service • Coalition of NGOs in Water and Sanitation • Community Water and Sanitation Agency • CSIR Water Research Institute (Ghana) • Danish International Development Agency (DANIDA) • FAO • Forestry Commission • GEMS/Water/BAFG • Ghana Environmental Protection Agency • Ghana Meteorological Agency • Ghana National Development Planning Commission • Ghana National Disaster Management Organization (NADMO) • Ghana Standards Authority • Ghana Statistical Service • Ghana Water Company Limited • Ghana Water Resources Commission	• GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) • Global Partnership for Sustainable Development Data • International Water Management Institute (IWMI) • Kwame Nkrumah University of Science and Technology • Ministry of Sanitation and Water Resources • The Development Institute • United Nations University Institute for Natural Resources in Africa • Université de Ouagadougou. URF Sciences de la Vie et de la Terre (UFR/SVT) • University of Energy and Natural Resources (UENR) • University of Fada N'Gourma (UFDG) • University of Ghana Departments of Chemistry, Earth Science, Marine and Fisheries Sciences • University of Ghana, Institute for Environmental and Sanitation Studies (IESS) • University of Ghana/SERVIR West Africa, Centre for Remote Sensing and Geographic Information Services • Volta Basin Authority • Volta River Authority • World Vision

ANNEX B – ONE-PAGE SUMMARY OF AFRICAN USE CASES VOLTA BASIN

UN environment

WWQA World Water Quality Alliance

Africa Use Cases Water Quality, Data, Services and Products: Co-Designing Three Pilot Cases in Africa

Mission Statement of World Water Quality Alliance:	**Context:**
The World Water Quality Alliance (WWQA) forms an open, global consortium, pooling expertise on water quality science and technology innovation. It aims at providing a participatory platform for water quality assessments and co-design of tailored and demand-driven services. It addresses priority topics relevant to water governance, scalable water solutions and emerging issues in water management.	The Use Cases provide an initial testbed that puts the quality of surface water and groundwater into the context of the local 2030 Agenda and its multiple linkages across the Sustainable Development Goals. The UN Environment Programme is cooperating with relevant organisations including the UN-Water Expert Group on Water Quality and Wastewater in the World Water Quality Alliance to develop a World Water Quality Assessment for consideration by UNEA-5.

Africa Use Cases Aim:

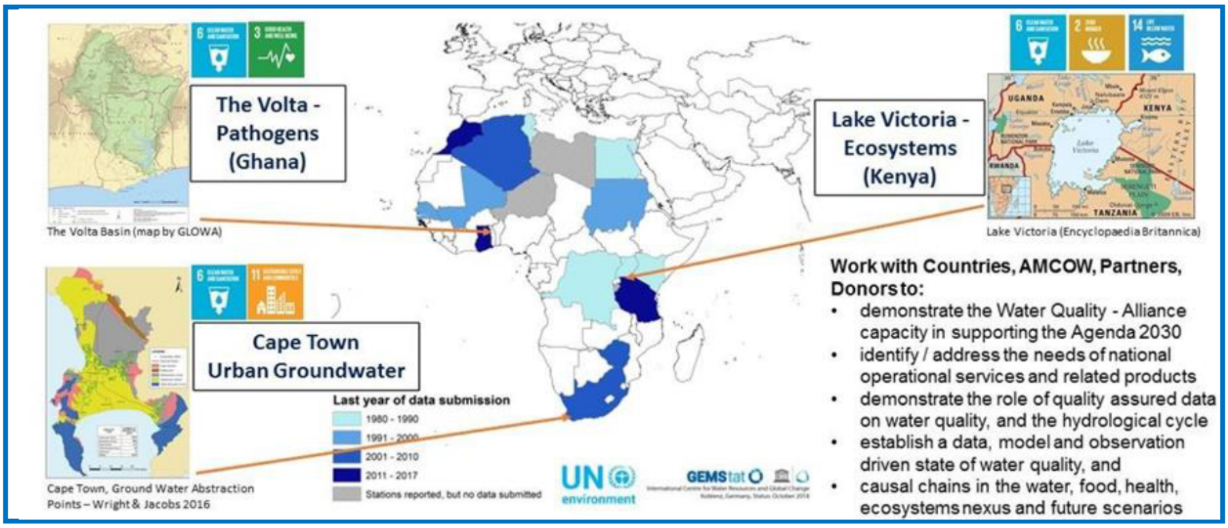
Build the "use case" for a World Water Quality Assessment by means of the piloting and demonstration of current capabilities, future information and services of the World Water Quality Alliance (the "Alliance") through these three case studies.

Central in these initial test cases will be the integration of in-situ, remote sensing-based earth observation and modelling data to derive the best possible current state of water quality (baseline). The objective is to provide an evidence base that links water quality hotspots to solutions and investment priorities. Crucial is a multi-stakeholder in-country driven process defining demand for water quality services (using experience in global problems to support local solutions). Stakeholders include government, academia, civil society and (inter)national organisations (quadruple helix).

Project Phases

Initiation Phase:	Identification Phase:
The network of contributing Alliance partners and local Use Case stakeholders is identified, and a rapid assessment of existing monitoring and assessment capacities and availability of data from multiple sources is conducted to determine the current state of knowledge and to set the objectives for the information services to be developed.	Existing data and information used to identify, categorise and undertake a preliminary (baseline) assessment of the quality status of the freshwater ecosystems by testing an innovative data/model fusion approach and further data analysis to develop pilot products and services for local/national application.

Use Case Study Areas



Volta River Basin

Includes six countries: Burkina Faso (43%), Ghana (42%), Togo (6%), Benin (3%), Mali (3%), Côte d'Ivoire (2%).

Surface water quality challenges:

- Nutrient load: highly localised from agricultural sources (plantations), markets, industries (beverage and textile), illegal mining activities
- Pathogens: from discharge of domestic waste, untreated sewage, open defecation (humans/animals)
- Sediments from declining natural vegetation

Groundwater quality challenges:

- Localised concerns, incl. fertilizer, sanitation, natural occurrences of heavy metals.

Copyright: GLOWA Volta 2007

Work Plan:

1 – Identify Stakeholders and Assess Capacity (Complete by Q4 2019)

- Collate information on existing databases among Alliance members (in situ, remote sensing-based earth observation (RS/EO) and modelling data; water quality products and services)
- Identify and record local Use Case stakeholders
- Assess Use Case capacity and gaps (capacities determined around enabling environment; institutions and participation; management instruments; financing) to assist in developing products and services.

2 – Set Visions and Objectives (Complete by Q1 2020)

- Consult local Use Case stakeholders (incl. inception workshop) to co-design with Alliance members the water quality data and information product(s).
- Compile Use Case databases of existing data for sharing among partners for targeted analysis

3 – Desktop Assessment (Complete by Q2 2020)

- Integrate water quality data in triangular approach (in-situ, RS/EO, modelling)
- Rapid baseline assessment of drivers, pressures & state of water quality to identify hotspots
- Develop co-designed water quality pilot products and services for present and future

4 – Conclusions and Outlook (Complete by Q3 2020)

- Review Results and Compile Outlook

ANNEX C – VOLTA BASIN WORKSHOP AGENDA

Day 1 – 25th February

9:00-10:30: Session 1

- Registration.
- Welcome, overview and purpose of the workshop.
- Round table introductions.
- Background to initiative.

10:30-11: Cocoa break

11-12:30: Session 2

- Panel discussion
  - Presentations made by key representatives to discuss the broad water quality challenges.
  - Discussions related to:
    - Water quality and health/cities.
    - Water quality and food.
    - Water quality and ecosystems.

13:30-13:30: Lunch

13:30-15:00: Session 3

- Open discussion:
  - Biggest water quality concerns in the Volta Basin.
  - Issues that need more research and information for more informed decisions.
  - User groups that would benefit from better data availability.

15:00-15:30: Cocoa break

15:30-17:00: Session 4

- Water quality data availability – who has what?
- Limitations to data sharing.
- Barriers or challenges which prevent the implementation of effective water quality solutions.

Day 2 – 26th February

9:00-10:30: Session 1

- Summary of day 1: Outcomes and directions for day 2.
- Challenges and opportunities for effective research implementation.

10:30-11: Cocoa break

11-12:30: Session 2

- Presentations/overview of:
  - In-situ citizen science data.
  - Water quality monitoring.
  - Earth observation and remote sensing.
  - Water quality databases.
  - Other data repository options.

13:30-13:30: Lunch

13:30-15:00: Session 3

- Products and services discussion.

15:00-15:30: Cocoa break

15:30-17:00: Session 4

- Discuss objectives and requirements for data and information products and services to be developed.
- Discussion on how to promote bottom-up social engagement process between in-country stakeholders and WWQA.

Day 2 – 27th February
9:00-10:30: Session 1
• Summary of day 1 and 2: Outcomes and direction for day 3. • Summary of key findings.
10:30-11: Cocoa break
11-12:30: Session 2
○ Discussion on best forum to discuss possible products/services. ○ Discussion on missing role-players to be included going forward. ○ Closure and thanks.
13:30-13:30: Lunch

Attendance List for the WWQA Expert Consultation on Volta Basin Use Case (25-27 February, 2020)

Institutions	Name
AMCOW	Patricie Leumeni
Burkina Faso Directorate General of Water Resources, Water Quality Service	Ouattara Cheick
Community Water and Sanitation	Gustav M. Osiakwan
CSIR, Water Research Institute	Anthony Yaw Karikari
EPA Ghana Environmental Protection Agency	Sam Adu Kumi
GEMS/Water/BAFG	Philip Saile
Ghana Environmental Protection Agency	Helina S. Dodd
Ghana Standard Authority	Francisca Frimpong
Ghana Standard Authority	Fiona Gyamfi
Global Partnership for Sustainable Development Data	Kenneth Mubea
Institute for Environment and Sanitation Studies	Gbedze Bright Yao*
Institute for Environment and Sanitation Studies	Christian Marilyn Ama Adoma*
Institute for Environment and Sanitation Studies	Annan Eugenia Ama Akofua*
Institute for Environment and Sanitation Studies	Dordaa Sampson**
Institute for Environment and Sanitation Studies	Ted Annang
Institute for Environment and Sanitation Studies	Millicent Amekugbe**
Institute for Environment and Sanitation Studies	Dan Nukpezah
IWMI	Boamah Edward Oppong
KNUST	Kwaku Amaning Adjei
National Disaster Management Organisation	Victor Addabor
The Development Institute	Ken Kinney
UFZ	Tallent Dadi
UN RCO	Gifty Tetteh
UNEP	Kornelius Riemann
UNEP	Andrew Gemmell
University of Energy and Natural Resources	Kabobah Amos.
University of Fada N' Gommal, Burkina Faso	Ouedraogo Issoufou
Volta River Authority	Philip Tetteh Padi
Water Resources Commission	Esi Biney

* Graduate Students from IESS
** Support staff for the meeting

ANNEX D –WORKSHOP TOPICS AND DISCUSSIONS

Issues that need more research and information for more informed decisions

Open discussions were held to share what issues the workshop attendees understood to require more research and information to be able to make more informed decisions on water quality. The identified issues are summarised below:

• Security of sampling in high-risk zones.	• Epidemiology, toxicology and eco-toxicology .
• Bio-indicators.	• Contaminants of Emerging Concern (CECs).
• Micro-plastics and impacts.	• How to assess data quality and reliability.
• Lab technician training and capacity building.	• Water quality standards specific to country.
• Sedimentation (e.g. reservoirs).	• Climate change and water quality.
• Groundwater governance.	• Economic valuation of water.
• Ecological water flow requirements.	• Re-forestation and water quality improvement.
• Desalination as an option for water supply.	• Phytoremediation (e.g. of mining impacts).
• Regular water quality monitoring (temporal & spatial).	• Laboratory accreditation and inter-lab accreditation.
• Artificial intelligence and assessment of lab quality.	• Standardisation of lab equipment and methods (via a standards authority).
• The Volta Lake trophic state (meso- or eutrophic?).	• Risk assessment: source-pathway-receptor linkages.
• Disaster risk, including from early warning to last line of reporting.	• Nature based solutions to improve water quality and water quantity.
• Mining impacts, including cross-border impacts and the extent of impacts.	• Saline intrusion, including impacts due to coastal zone abstraction (e.g. for agriculture use).
• Improvement in the art of data visualization to make science more understandable and engaging.	• Plant based water treatment methods (e.g. Moringa being having anti-microbiological action and assisting in coagulation).
• Land-use/land-cover change and impacts to aspects such as water quality linkages, and groundwater recharge.	• Impacts of on-site sewage treatment systems on groundwater (e.g. soakaways intercepting the water table).
• Changes to water availability for drinking supply. Surface water volume estimations. Assessment of the location and volume of groundwater resources.	• Water treatment of natural and anthropogenic impacts using local water supply and materials (as opposed to piped water).
• Improvement in the art of data visualization to make science more understandable and engaging.	

User groups that would benefit from better data availability

Open discussions were held to share opinions on which user groups would most benefit from an improvement in water quality data availability. These users were identified (in no particular order) as:

• Agriculture extension officers.	• Water regulators and researchers.
• Developers of water quality standards.	• District-level decision makers.
• Aquaculture farmers (inland fisheries).	• Ghana Water Company.
• Policy makers.	• NGO's.
• Health centres.	• Community Water and Sanitation Agency.
• Laboratories.	• Borehole drillers.
• Gender and the access/selection of water sources.	• Global data repositories, local data repositories.

Volta Basin Water Quality Data Holders and Providers

Through open discussions with the workshop attendees, the primary water quality data holders and providers within the Volta Basin were identified. These are summarised below:

• Burkina Faso:	
○ Directorate General of Water Resources.	○ Irrigation Development Authority.
○ National agencies of water.	○ Ministries of Water and Sanitation.
○ National Laboratory for Water Analysis.	○ Niger Basin Authority (NBA).
○ National Office for Water and Sanitation.	○ West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL).
• Ghana:	
○ CSIR-Water Research Institute.	○ Environmental Protection Agency.
○ Hydrological Services Department.	○ Ghana Water Company Limited.
○ Water Research Institute.	○ Water Resources Commission.
○ Volta River Authority.	○ Community Water and Sanitation Agency.
○ National Disaster Management Organisation.	○ The German Federal Ministry of Education and Research program “Global Change and the Hydrological Cycle” (GLOWA).
• International Institute for Water and Environmental Engineering (2iE).	
• Water drilling companies.	
• NGO’s.	
• AMCOW, including a data officer (quality).	
• Citizen science.	
• Hydro power generators.	
• Public and private laboratories.	
• Universities.	

Data Repositories

The available data repositories were discussed and summarised. In addition, based on feedback from stakeholders both before and after the workshop, other available data repositories were identified. These are all summarised as follows:

• Ghana Central Intelligence Agency (CIA).
• International Atomic Energy Agency (i.e. isotopes).
• Data repositories maintained by Ghana Water Resources Commission.
• Volta Basin Information Sharing System (VBISS).
• IUCN Central and West Africa Programme (PACO).

VOLTA

• http://gefvolta.iwlearn.org/project-resources/studies-reports/tda-final/regional-tda/volta-basin-tda-english GEF-Volta Project, with water quality descriptions, as well as tabulated results)
• https://sanitationghana.org/map/ Basic Sanitation Information System – BASIS for Ghana. This includes access to formal sanitation data.
• Volta HYCOS (https://hydrohub.wmo.int/en/projects/Volta-HYCOS). Hydrological Cycle Observing System (HYCOS) specific to the Volta Basin area.

AFRICA/GLOBAL

• International Groundwater Resource Assessment Centre (IGRAC) databases, specific to groundwater
• Group on Earth Observation (GEO) Portals (https://www.geoportal.org/)
• AMCOW tools, including Africa Water Sector and Sanitation Monitoring and Reporting (http://www.africawat-sanreports.org)
• RAMSAR database (wetlands)
• http://www.africawat-sanreports.org/IndicatorReporting/home Africa Water Sector and Sanitation Monitoring and Reporting

• https://doi.pangaea.de/10.1594/PANGAEA.871462 Diversity II water quality parameters for 300 lakes worldwide from ENVISAT (2002-2012).
• https://www.bafg.de/GRDC/EN/Home/homepage_node.html Global Runoff Database
• https://www.servirglobal.net/ServiceCatalogue/list SERVIR RS/EO data split into regions and service areas, and data source.
• http://52.54.26.108/ RS/EO data by the Africa Regional Data Cube
• https://www.arcgis.com/apps/Cascade/index.html?appid=414730116a3c4c119b80ec9d1727ab74 GEOGLOWS Global River Forecasting Applications
• World Bank tools such as
o http://spatialagent.org/HydroInformatics/
o http://appsolutelydigital.com/MonitoringSystems/hydrology.html
o http://spatialagent.org/Africa/
o https://geo.fas.usda.gov/GADAS/index.html USDA - Foreign Agricultural Service Global Agricultural & Disaster Assessment System

Challenges for effective research and implementation

• Political will.	• Sharing data.
• Separation of power.	• Monetization of data.
• More researchers in water resources. Aging human capital.	• Better industry engagement. Industry supporting research.
• Quality of data, including quality control and quality assurance.	• Maintenance of monitoring stations. Lack of maintenance culture.
• Data-sharing within institutions (e.g. within a university) so not to duplicate efforts.	• Effective communication to policy/decision makers, including improving impact of research.
• Funding. This includes insufficient industry funding. A need to prove capabilities to best utilize funding towards success.	

Opportunities for effective research and implementation

• Capacity building.	• Science-policy interface.
• Knowledge dissemination.	• Better research into water quality, land use etc.
• Funding, including for students towards data collection.	• Industry social responsibility (e.g. off-shore oil companies).
• Lab capacity, standardization, better lab equipment.	• Scholarships to be focused on highlighted issues/hotspots.
• Municipality engagement, including related to illegal dumping.	• Increased water quality monitoring (e.g. by Ghana water company).
• Industry/research disconnect. Solutions take time to research.	• International community exposure to Africans (in country and abroad) and collaboration.
• Policy and legislation towards funding of research. Insufficient current provision by government.	• Impact stories. Media involvement. Improved influence. Solving real-world problems for real impact.
• University centres of excellence (i.e. EO/RS, modelling etc). Combined capabilities between universities and cross-border. African World Bank centre for excellence.	• Collaboration, including cross-border collaboration; collaboration between industry and research to improve data sharing/availability; students assigned to industry to design solutions.
• Improve skills in communicating research to industry with content that is easily digested/understood.	

Identification of Participant Water Quality Requirements

To work towards identifying potential water quality products and services, the water quality needs were discussed with the workshop participants. To guide these discussions, the participants were split into three groups: Academic, Government and NGO/IGO role-players. The groups discussed their needs amongst themselves, and then responses were discussed and enhanced through further combined workshops. The water quality requirements as discussed and agreed are as follows:

• Methods to assess nutrient loads	• Mine impacts (e.g. acid mine drainage)
• Algae identification methods	• Improved aquatic invasive monitoring
• Field trip(s) with stakeholders and partners	• Combined impacts of chemical cocktails.
• Water quality database options	• Impacts to indigenous fish from aquaculture
• Mine rehabilitation	• Improved sanitation technologies
• Develop an information platform	• Develop impact stories
• Wetland rehabilitation	• Wetland encroachment management
• Good water governance	• Sustainable funding and long-term investment
• Develop sustainability plan	• Training in the basics of data (metadata, database options, QA/QC etc.)
• Policy harmonization and the science-policy link.	• Validation of water quality results (quality assurance/quality control – QA/QC)
• Development of water quality standards (based on data)	• Understand causal chain between water quality and public health
• Realtime monitoring (water quality and levels/flow)	• Migration/pastoralization/land-use impacts (e.g. nutrient loads)
• Monitor water quality, including cross-border impacts.	• Develop a stakeholder engagement plan – including partner organisations in WWQA
• Assessment methods for point and non-point pollution sources	• Techniques/equipment to measure flow and suspended solids to assess sediment load
• Communicate results. Publication of at least one research paper from the Africa Use Cases project	• Publication of an annual/biannual state of freshwater report in Africa
• Longitudinal studies (spatial/temporal e.g. look at a watercourse from source to discharge to ocean to assess impacts)	• International institution for tropical agriculture to capacitate labs (local support to local capacity building
• Methods to increase in situ monitoring points: citizen science, cheap meters/methods, apps to assess water quality etc.	• Improved understanding of populations vulnerable to water quality impacts (incl. flooding)
• Lab facilities for primary contaminants in water and wastewater (heavy metals, antibiotics, Contaminants of Emerging Concern (CECs), microplastics, nutrients)	• Gap analysis of lab and equipment. Concern of expired chemicals/reagents. Investigate options to share un-used lab equipment between laboratories
• Align with disaster management to assess risks to communities by poor water quality (location of community, population, health, access to water, sanitation status, etc.	• Coordination in water space: Technical expertise not working in harmony, silo's. Understand why harmonization/coordination not occurring (e.g. organizations saving only to personal computers, policy implementation, cross-border impacts, staffing numbers)
• Groundwater	
○ Validation of groundwater data	○ Geogenic issues (e.g. fluoride)
• Remote Sensing Earth Observation – provision of:	
○ Baseline maps	○ Opensource tools
○ Land use impacts (mining, deforestation, markets; including extent and rate of change)	○ Flood risk (including climate change)
• Modelling – provision of:	
○ Opensource tools for modelling ○ Flood risk and vulnerability (including climate change)	○ Nutrient inputs

• Capacity building:	
○ Monitoring	○ Technicians
○ Citizen science	○ Data analysis
○ Modelling	○ Remote Sensing Earth Observation
○ Long-term capacity building e.g. scholarships	○ Contaminants of Emerging Concern (CECs)
○ Organize a learning event as a result of the capacity-building	○ Capacity building rather than cost-saving (e.g. in-country lab analysis)
○ Influence school curriculum on water quality (e.g. integrated science subject)	

Additional role-players to be included going forward

While the workshop aimed to include as many key stakeholders as possible, not all were able to attend due to time and logistical limitations. As a result, the following role-players were proposed by the workshop attendees to be included going forward:

• Ghana Statistical Services	• Ghana Water Company,
• Ghana Atomic Energy Agency	• Mining via the Ghana Minerals Commission
• Ghana local government	• Ghana Meteorological Agency (GMet)
• SDG solution centre (Accra, Ghana)	• Burkina Faso National Water Agency
• Burkina Faso Universities	• Volta Basin Authority
• Niger Basin Authority (learning shared between basins)	• Drilling contractors (for groundwater information)
• Economic Community of West African States (ECOWAS) as part of political mandate	• Sustainable development planning via the Ghana National Development Planning Commission
• NGO's such as WaterAid, World Vision International, Adventist Development and Relief Agency, SNV	• Centre for Remote Sensing and Geographic Information Services (CERGIS) based in Accra, Ghana
• Burkina Faso: 2iE, UNICEF, PlanBurkinaFaso (NGO), Catholic Relief Service (CRS), Red Crescent/Cross, Ministries of Water, Education, Research, Health	
• Ghana Ministries such as Ministry of Education, Ministry of Sanitation and Water Resources, Ministry of Environment, Science, Technology and Innovation, Ministry of Works and Housing Hydrological Services Department. Ministry of Food and Agriculture, Ministry of Health, Ministry of Fisheries and Aquaculture Development; Ministry of Land and Natural Resources	