

Contributing to the achievement of sustainable development goals: knowledge on water, sanitation and health risk in Cotonou and Lomé cities

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ABSTRACT

The paper explores how a project implemented in the framework of the LIRA2030 Africa programme is contributing to the achievement of the Sustainable Development Goals (SDG) on water, sanitation and health in the West African coastal cities of Cotonou (Benin) and Lomé (Togo). Based on co-produced knowledge on water, sanitation and health risks, collected through a transdisciplinary approach, we investigated socio-ecological sanitation and the applicability of an Ecohealth model to support SDGs 3, 6 and 11. According to our findings, the basis for the achievement of SDGs in these cities lies in addressing bad sanitation and hygiene related to a linear urban metabolism, poor groundwater quality and the occurrence of health risks (malaria, gastroenteritis, diarrheal). In this regard, the projects contributed by developing socioecological sanitation facilities for groundwater quality improvement and protection and for health risk reduction. An Ecohealth model was also developed to help improve and maintain the quality of groundwater in the study cities to promote healthy living and for sustainability. Social impacts of the SDG achievement could really help in sustainable development and the well-being in the coastal West African cities.

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1. Introduction

The sustainable development goals (SDGs) can be a basic framework for sustainability in countries where, according to Croitoru et al. (2019), unsafe water, sanitation, and hygiene are particularly harmful, causing more than 10,000 deaths per year. The goals were adopted in 2015 for the period 2016–30 (Morton et al. 2017) and aim to provide guidance and contribute effectively to transformative changes ‘in support of a rights-based, equitable and inclusive approach to sustainability at global, regional, national and local levels’ (UNECA, AU and AfDB, 2013). It served as a powerful medium which provided member states with a feasible development pathway ensuring a balance between the economic, social and environmental dimensions of sustainable development (Khalid et al. 2018; Sachs et al. 2019). To achieve the SDGs, all states are called upon to integrate the goals into their national sustainability and development plans (United Nations 2017) to eradicate poverty, increase socioeconomic inclusion and protect the environment.

This new road of development is that explored by the Leading Integrated Research for Agenda 2030 in Africa (LIRA2030 Africa) programme, with a mission that seeks to increase the production of high-quality, integrated (inter – and transdisciplinary), solutions-

oriented research on global sustainability. Launched in 2016, this programme, implemented by the International Science Council (ISC 2020), fosters scientific contributions from Africa on the 2030 Agenda for Sustainable Development, especially in urban areas. To this end, the LIRA2030 Africa programme draws African cities such as Cotonou and Lomé toward sustainability, based on the SDG 11 (sustainable cities and communities) in addition to others such as SDGs 3 (ensure healthy lives and promote well-being for all at all ages) and 6 (ensure availability and sustainable management of water and sanitation for all). The (ISC) (2020) explains that African cities have a unique but often overlooked capacity to innovate and experiment with solutions for sustainability. These cities often include complex but agile informal settlements and multiple ecologies with resources that offer alternative pathways to the implementation of the global development agenda (Buyana 2019; Kovacic et al. 2019). Urama et al. (2014) reported that Benin already has policies, strategy and action plans on sustainable development issues in areas, such as water and the environment. For example, there is Decree No. 2016–220 (4 April 2016) establishing an institutional framework to achieving the SDGs; Decree No. 2019–547 (11 December 2019) on the attributions, organization

and functioning of the Ministry of Environment and Sustainable Development; Decree No. 2011–574 (31 August 2011) establishing the National Water Council. Others include the National Sustainable Development Strategy; the Government Action Programme, the National Development Plan; the National SDG Targets Prioritization report, etc. However, the current state of practice with respect to stakeholder participation and strategy planning shows those countries in Africa are at different levels of engagement with stakeholders for sustainable development. So, the LIRA2030 Africa funded projects are a complementary effort of SDG implementation at the city level through the establishment of multi-stakeholder dialogue using transdisciplinary research (Schneider and Buser 2018) at local scales in recognition that urban challenges require novel methods of knowledge production (ISC 2020).

This vision of LIRA2030 is confirmed by Andreoni and Miola (2016), Klopp and Petretta (2017) who highlight the importance of stakeholder participation in SDG implementation. Assessment of knowledge on the impacts of urban environment governance, sanitation, water quality degradation and on public health requires community-based contribution. Working with different stakeholders helps researchers to have a better understanding of local needs and interests, to gain a holistic understanding of problems, and to co-produce locally grounded knowledge and solutions (ISC 2020).

Co-produced knowledge is used to address complex sustainability challenges in the coastal African cities of Cotonou and Lomé. African cities are home to micro-scale innovations and local community action that have demonstrated approaches for leapfrogging to cities that are sustainable, inclusive and resilient (SDG 11) (Patel et al. 2017; Arfvidsson et al. 2017; Valencia et al. 2019). Social impacts of the LIRA2030 funded projects are evaluated as science effectively contributing to the implementation of the New Urban Agenda and the achievement of SDGs in these cities. An integrative implementation approach typically begins with identifying causal relationships between goals and policies (Collste et al. 2017).

The objective of this paper is to assess how the LIRA2030 programme is contributing efficiently to the implementation of the global agendas, notably the SDGs on water, sanitation and health at the local level in the coastal cities of Cotonou and Lomé. According to UNDP, UCLG, UN-HABITAT (2016), localizing is the process of taking into account subnational contexts in the achievement of the 2030 Agenda. We explore the Ecohealth approach in a bid to promote health, water, sanitation and hygiene. This approach can contribute to new scientific knowledge and innovation, reinforce community empowerment and initiatives, and promote policy change (Charron 2011). Also, ecosystem

(Ecohealth) approaches to human health are promising avenues for exploring long-term solutions to the kind of complex (or 'wicked') problems developing countries are facing (Golden and Earp 2012) mostly in their cities.

2. Data and methods

Study area

Cotonou and Lomé, located in Benin and Togo, respectively, in West Africa (Figure 1) are the most populated urban cities of their respective countries with 760,000 inhabitants (2013) in Cotonou and 837,437 inhabitants (2010) in Lomé. The high urban population density, 14,591 people/km² in Cotonou and 11,985 people/km² in Lomé, is of important interest with regard to SDGs 3, 6 and 11. The poor planning, existence of informal settlements, and the inadequate basic socio-community infrastructures for water supply, sanitation and hygiene (WASH) influences public health and population wellbeing. In addition to natural factors, the indiscriminate disposal of waste by humans can contaminate aquifers and cause flooding (resulting from choked drains).

The complex environmental, social and economic context of the two cities offer a basis for evaluating the contribution of the LIRA2030 program to the achievement of SDGs 3, 6 and 11 in the two cities.

Data

Data on well water use, bacteriological and physico-chemical quality, sanitation and hygiene practices, and public health were collected from local field visits, observations on the status of the environment and wells, interviews on households with 115 persons per city, focus group discussions, sampling of well water and quality assessment. These data sets helped in systemic analysis with regard to targets of SDGs 3, 6 and 11. Complementary data on urban ecology and groundwater pollution were obtained from existing literature (Ahatefou et al. 2013; Tampo et al. 2014; Soncy et al. 2015; Totin Vodounon 2020).

Basis for analysis of contribution to the achievement of SDGs in the two cities

In addition to the use of current knowledge (literature) on the status of water quality, sanitation, hygiene and public health risks, co-produced knowledge on water, sanitation and hygiene within the project LIRA2030-GR05/19 Cotonou-Lomé served as a basis for the analysis of SDGs achievement in the two cities.

The selected SDGs (3, 6 and 11) were analysed by the target retained at a country level and by the target aligned with the LIRA2030 Africa's objective of contribution to sustainable development mostly at the city scale.

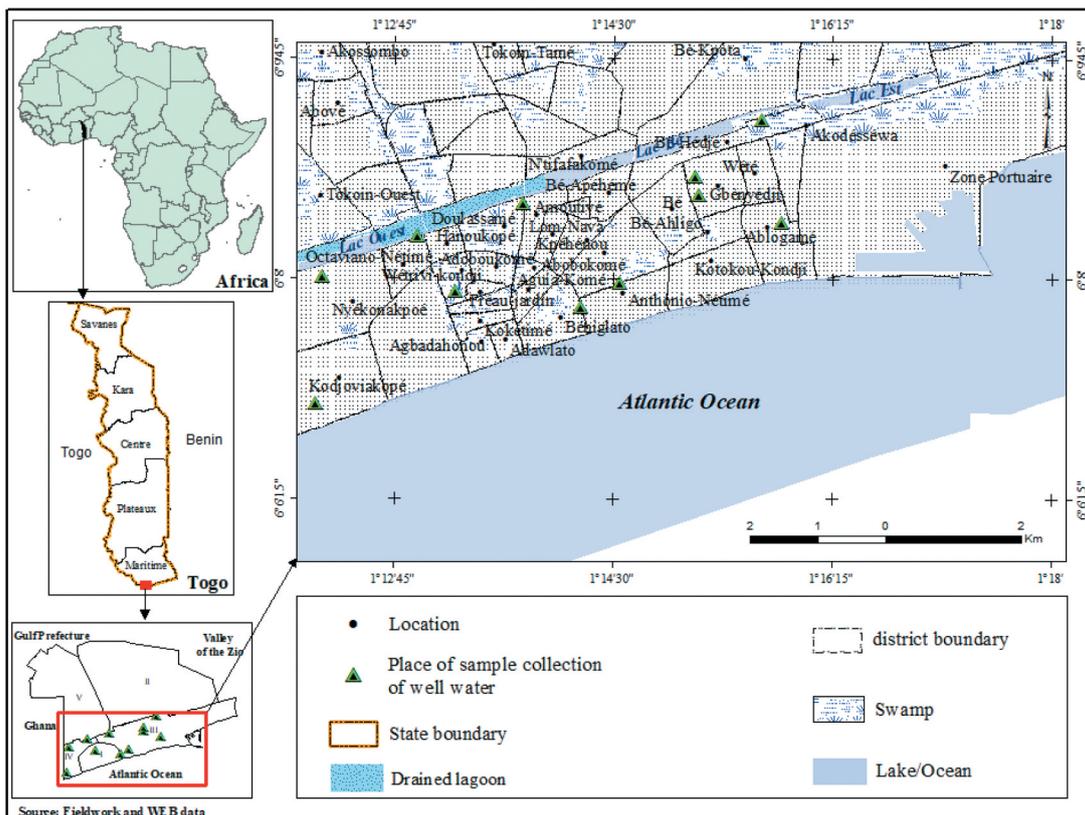
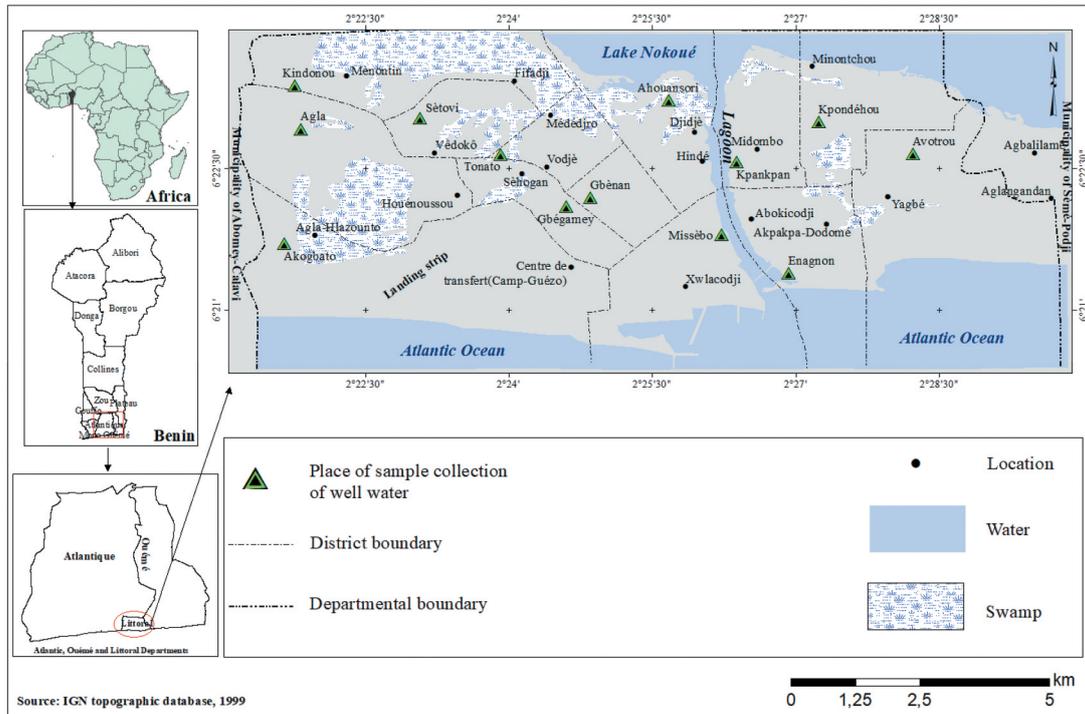


Figure 1. Geographical location of the cities of Cotonou (a) and Lomé (b).

Elaboration approach of Ecohealth model

Ecohealth (Parkes et al. 2014), an analytical model for research action based on the ecosystemic approach to human health (Arredondo and Orozco 2012), shares strategies for community participation and empowerment for the solution of health problems (Charron 2012).

In this framework, a transdisciplinary approach (Lang et al. 2012; Jahn et al. 2012; Mauser et al. 2013; Brandt et al. 2013; Marshall 2014) involving all stakeholders of the implemented LIRA project helped to co-design, co-create and co-produce the Ecohealth model (Charron 2012; Wilcox et al. 2012; Arredondo and Orozco 2012; Harrison et al. 2019). The LIRA2030

Africa program has developed a transdisciplinary research approach as a strategy to contribute to the SDGs.

The Ecohealth model is adaptable in the context of the two cities since it supports pathways on how improved human health can be attained from better groundwater and waste management. The main questions related to the Ecohealth model in our study are related to the epidemiological situation of Cotonou and Lomé linked to unsafe water, occurrence of water-borne and environmental diseases and the most appropriate solutions to improve WASH and public health in the two cities.

This research has been approved by the Ethical Committee of Biomedical Research, University of Parakou, Benin (Ref. No. 0299/CLERB-UP/P/SP/SA of 14/05/2020). Informed consent was obtained from each participant before their inclusion on the transdisciplinary research team.

3. Results and discussion

Legal regime on water and sanitation in Benin and Togo

By recognising the human right to water and sanitation, the government of Benin adopted the National Water Policy in July 2009, and promulgated Law No. 2010–44 of 24 November 2010 on Water Management. In Togo, this framework is defined by Law No. 2010–004 (9 June 2010) on Water Management and the Law No. 2010–004 (14 June 2010) on the Water Code, a legal basis for water policy. The sanitation sector is regulated by the National Hygiene and Sanitation Policy of Benin (PNHA) and of Togo (PNHAT). These policy documents backed by Law No. 2011–24 of 4 July 2011 (which is an amendment of Article 16 of Law No. 2010–006 of 18 June 2010 on the organization of public services of drinking water and collective sanitation of domestic wastewater in Togo), Law No. 87–15 of 21 September 1987 on the code of public hygiene, and Decree No. 97–616 of December 1997. Law No. 98–030 of 12 February 1999 defines the basis of the national environmental policy and organizes its implementation in accordance with the constitution of Benin. We also have Law No. 2008–005 of May 30 establishing the Environmental Framework Law. The main institutional actors that intervene in the water and sanitation sectors are public and private and operate in the reference framework of the SDGs including SDGs 3, 6 and 11. The SDGs for poverty eradication in Africa (Nhamo 2017) need effective partnerships or collaborations (Ekhatior 2019).

There have been several reports on the implementation of SDGs in Benin and Togo. Examples are the '2018 Shadow report by the civil society of Benin' on

experience on the SDGs, 'Report of participation of Benin in the 2020 High Level Political Forum' and 'Report of participation of Togo in the 2017 High-Level Political Forum' on Sustainable Development to share progress, good practices, experiences and the future vision for the implementation of the 2030 agenda and its SDGs.

Status of water, sanitation, hygiene and public health: basis for SDGs 3, 6 and 11 implementation

Water quality status in Cotonou and Lomé

The main sources of water supply in Cotonou and Lomé are private domestic wells and the urban network of the National Water Company. A large part of the citizens use well water for laundry, dish washing, bathing and cleaning. Sometimes this source of water also serves for drinking purposes because of inadequate availability of safe water networks, bad socio-economic conditions and shallow groundwater (0.5 to 2 m) availability.

The water quality analysis revealed physicochemical and bacteriological pollutants in the domestic wells that are often unmaintained and unprotected. Water samples from the wells in Cotonou indicated that the quantities of HCO_3^- , NH_4^+ , total hardness exceeded the WHO (2017) allowable limits. In Lomé, quantities of Ca^{2+} , NO_3^- , NH_4^+ and conductivity were exceeded. The analysis also indicated faecal pollution in wells in both cities. Microbiological parameters showed thus a non-compliance of well water to total coliforms, *Escherichia coli*, faecal streptococci and enterococci and to the sulphite-reducing clostridia in 100% of cases.

Higher concentrations of bacteria in well water (Totin et al. 2013; Soncy et al. 2015) are related to poor sanitation and unhygienic practices which induce the recharge of shallow aquifers with wastewater thereby contaminating them. The deterioration of groundwater quality, however, depends on the physical properties of the environment as well as the climatic context. The superficial character of the quaternary sandy aquifer that feeds the wells in Cotonou and Lomé increases its vulnerability to various sources of pollution and infiltration of micropollutants into groundwater (Dégbey et al. 2010; Yapo et al. 2010). With higher rainfall (1300 mm/year in Cotonou and 800 mm/year in Lomé) and the cities' connection to lakes, lagoons and rivers, annual floods that accelerate water quality deterioration through diffuse pollution from inappropriate and informal sanitation and hygiene disposal sites in Cotonou and Lomé. Azzellino et al. (2019) confirmed anthropogenic influence due to diffuse pollution on groundwater status in highly urbanized areas. Poor physicochemical quality leads to long-term risks while those in the short term are linked to the

microbiological quality (Kopa Njueya et al. 2012). Among the anthropogenic factors causing the deterioration of bacteriological quality of well water, poor sanitation and hygiene infrastructures play a key role and remain critically important.

Status of sanitation and hygiene in Cotonou and Lomé

Bacterial pollution of well water in the West African coastal cities (Yapo et al. 2010; Soncy et al. 2015; Totin Vodounon 2020; Eka 2020) is linked to the absence of proper sanitation facilities in precarious neighbourhoods, defectives septic tanks, waste deposits, and the close location of toilets and pit latrines (5 to 10 m) to the wells (Figure 2).

The spacing of the urban houses does not facilitate compliance with the conventional distance of 15 m between wells and latrines in order to avoid aquifer contamination. In addition, a major characteristic of sanitation facilities in households in the two cities is the lack of septic tanks, which when present are mostly not waterproof. In such instances, it is very easy for bacteria pollutants resulting from poor sanitation and hygienic practice to be transferred to groundwater from wells which develop internal cracks over time.

Current development of cities, such as Cotonou and Lomé, associated with insufficient infrastructure, lack of maintenance of gutters, bad hygiene and sanitation practices, construction of leaky pits within households and non-respect of the safe distance between wells and latrines, leads to a critical situation for neighbourhoods located near lagoons, lakes and the ocean.

Water system contamination correlated with the high level of environmental pollution illustrates the bad appropriation and use of urban land by people in West African cities. According to the stakeholders, urban pollution originates from solid and liquid waste, excreta and floods in the complex coastal cities with constantly waterlogged sandy soils. From our investigation, about 65.7% of urban population evoke unhealthy relation to poor sanitation practices (55.5%),

household solid waste (45.5%) and wastewater management (33%). Solid waste management techniques are burying, discharge into gutters, bridging the swamp and burning, which all affect the environment and human health. Wastewater is mostly discharged on sump, poured on the streets, gutters and courtyards of houses, while pit latrine and septic tank dominate excreta management disposal. Infrequent collection of municipal waste in West African coastal areas is a major challenge, leading to bad odours, pollution of the environment (e.g. water) and potential health problems (Croitoru et al. 2019).

Sanitation and hygiene systems (which are the responsibility of individuals) are often outdated, poorly constructed, inappropriate or poorly maintained. Plumbing systems are also mostly very poor. The lack of latrines and maintenance of garbage cans, dumping of waste on swamps, street, gutters and lagoons without prior treatment reflects the level of knowledge on hygiene and sanitation in the coastal cities, mostly in the slums.

Some sub-Saharan African countries have only around 10% of their populations connected to a sewer system (Banerjee and Morella 2011). Indeed, almost 85% to 90% of global wastewater is discharged without treatment (Corcoran et al. 2010) in urban areas. Wastewater generation is one of the biggest challenges associated with the growth of informal settlements (slums) in developing countries (WWAP 2017) such as Benin and Togo with their respective big towns, Cotonou and Lomé. To this end, West African coastal cities are confronted with the problem of a lack of adequate and adaptable infrastructure that supports sustainable sanitation and hygiene. Another origin of poor sanitation practices is poverty and unconsciousness of the implications of poor sanitation on quality of water supply from the wells. Indeed, insufficient or inappropriate water supply, sanitation, and hygiene (WASH) can affect human health (due to water-borne diseases) and the environment (due to discharge of untreated wastewater) (Croitoru et al. 2019) of complex urban areas as the coastal cities.



Figure 2. Toilets close to the wells in a) Cotonou (Ahouansori Towéta) and b) Lomé Béniglato (Photos: a) H.S. Totin Vodounon, January 2021; b) A. B. Eka, June 2020).

Health risks related to unsafe sanitation and water in Cotonou and Lomé

Poor sanitation and related unsafe water constitute a threat to public health, according to 99% of urban residents in Cotonou and Lomé. They cause water-borne and primarily, diarrhoeal diseases (Khatri and Vairavamorthy 2007), the most common symptom of gastrointestinal infection (Ahs et al. 2010), cholera, etc. Unhealthy urban environment in West Africa leads to the establishment of breeding sites for malaria vectors, multiplication of mosquitoes, flies and rodents which constitute vectors of disease. The residents of Cotonou and Lomé risk contracting diseases such as malaria, cholera, typhoid fever, yellow fever, diarrheal, infections, gastrointestinal disease, dermatological infections, urinary tract infections, and so on.

Water-borne diseases are linked to bad sanitation conditions, lack of improper hygienic practices (not washing hands, poor cleaning of water supply systems, etc.), consumption of contaminated water, and the presence of stagnant water and garbage dumps around one's habitat. According to UNICEF (2016), poor water, sanitation and hygiene are the main causes of faecally transmitted infections (FTIs) such as cholera and diarrhoeal disease. The great majority of evident water-related health problems are evoked by the (2017) to be the result of microbial contamination and the ability of chemical constituents to cause adverse health effects after prolonged periods of exposure.

Unsafe sanitation and hygiene and contaminated water use constitute a health risk in coastal cities and are a challenge to the achievement of the SDGs.

Project contribution towards the achievement of SDGs 3, 6 and 11

Pathways of the SDG implementation developed by LIRA2030 Africa in Cotonou and Lomé

In their 2020 SDG Index Ranking for Africa, the Sustainable Development Goals Centre for Africa and Sustainable Development Solutions Network (2020) estimated an Index Score of 53.53 for Benin and 54.41 for Togo. According to the West Africa SDG dashboard and trends, Benin is making moderate progress in achieving SDG 3 but faces major challenges. There is stagnation in the achievement of SDGs 6 and 11, and major challenges remain.

With regard to Togo, progress towards the achievement of SDGs 3 and 6 indicate moderate increases with major challenges. For SDG 11, major challenges remain and progress towards achieving this goal is decreasing. Hence, the SDG dashboard and trends reveal that the selected SDGs are far from being achieved. The performance by indicator for each of the countries is synthesised in Table 1.

Table 1. SDGs and Performance by indicator in Benin and Togo.

SDG	Performance	
	Benin	Togo
SDG3 Good Health and Well-Being	61.7 (2018)	65.1 (2018)
SDG6 Clean Water and Sanitation	66.4 (2017) 16.5 (2017) 0.0 (2018)	65.1 (2017) 16.1 (2017) 0.0 (2018)
SDG11 Sustainable Cities and Communities	54.2 (2017)	44.7 (2017)

Adapted from Sustainable Development Goals Center for Africa and Sustainable Development Solutions Network (The Sustainable Development Goals Center for Africa and Sustainable Development Solutions Network 2020)

Local initiatives are necessary to help in improving performance towards the achievement of the SDGs. UNDP (2018) explains that localization involves 'concrete mechanisms, tools, innovations, platforms and processes to effectively translate the development agenda into results at the local level'. With the bottom-up approaches, Smith et al. (2018) explain that despite the need for global outcomes, most implementation of the SDGs will be local.

So, the purpose of this paper is the implementation of SDGs related to WASH and public health at the local level in the cities of Cotonou and Lomé. The pathways and actions taken to support the achievement of SDG 3, 6, 11 and associated targets in both cities are presented in Table 2.

Concrete project contributions to the SDGs in Cotonou and Lomé

An assessment of the status of WASH and health risks helped in carrying out concrete actions in the pilot sites in Cotonou and Lomé. The key actions taken with regard to sanitation are the promotion of disposals that prevent contamination of water systems. Examples include polyethylene septic tanks, above-ground watertight pit latrine and dry toilet (Figure 3). These disposals were developed by the urban dwellers.

These ecological sanitation disposals for excreta management ensure that groundwater quality is not compromised in Cotonou and Lomé and could be developed in the West African coastal cities. Also, at the household or neighbourhood level, phytopurification of wastewater is done using *Eichhornia crassipes* (water hyacinth), a technique inspired from ongoing experimentation of Songhai Centre in Benin and NGO ENPRO (Safe Natural Ecosystem) in Togo that provides training for urban residents.

Given that the well is a source of water mostly used by urban communities and that its quality is bad, low-cost treatment techniques are developed. The purpose is to disinfect domestic water taken from the wells and to increase its accessibility. To ensure good water quality, purification methods, such as continuous chlorination using calcium hypochlorite ($\text{Ca}(\text{OCl})_2$) diffuser

Table 2. Contribution to the achievement of SDGs in the cities of Cotonou and Lomé.

Goals	Targets	Contribution
SDG 3 Good Health and well-being	3.3.	Improving sanitation and hygiene facilities Promotion of low cost wastewater treatment techniques Environmental education for behaviour change
	3.9.	Co-produced knowledge on current sanitation and hygiene system and related health risks Monitoring of groundwater bacteriological and physicochemical quality Promotion of socio-ecological sanitation and groundwater quality treatment Education-Information-Communication for social change on sanitation and hygiene Lead local efforts on waste valorisation by circular economy development
	3.d.	Control of sanitation and hygiene disposal Implementation of developed ecohealth model Control of drinking water quality Timely and appropriated information to city residents through virtual platforms
	6.1.	Encouragement to improve groundwater quality or get water from the National network of safe water
SDG 6 Clean Water & Sanitation	6.2.	Use of ecological disposal for waste and excreta management Promotion of hand-washing facilities
	6.3.	Implantation of the chlorinator (hypochlorite of calcium) for continuous destruction of microbial contaminants Use of Aquatabs water purification tablets Use of ecological disposal for waste and excreta management Promotion of circular economy
	6.4.	Co-produced knowledge on groundwater quality Advise on efficient use of groundwater and safe water from national network
	6.5.	Promotion of integrated sanitation and hygiene for groundwater security in the coastal cities Recycling and reuse of treated urban wastewater
	6.6.	Promotion of ecological sanitation practices for aquifer rehabilitation and protection
	6.a.	Synergy of actions between Cotonou, Lomé and other West African coastal cities Sharing of experience on WASH and public health and implementation of developed Ecohealth model
	6.b.	Using transdisciplinary research approach Training of specialists (on WASH and health) Active pedagogy (Strategy of doing things) Training of the local politico-administrative authorities
	11.5.	Promotion of adequate waste management systems to create agreeable living urban environment
	11.6.	Behaviour change Information, Education and Communication on WASH and public health Ecological waste management
	11.a	Creation of action synergy between local politico-administrative authorities in Cotonou and Lomé Co-design of inter-municipality management of waste Development of policy briefs on integrated sanitation and hygiene, applicable to the West African coastal cities
SDG 11 Sustainable cities & communities	11.b.	Co-produced knowledge on hydro-faecal risk and its management during floods Dissemination of research results in others coastal cities Implementation of the recommendations of policy briefs produced Sustainability of education on environment and integrated urban groundwater management

disposal (Figure 4), aquatabs water purification tablets and water ebullition are used to treat well water containing bacterial pathogens.

Calcium hypochlorite is a disinfectant used in water treatment where it acts as an oxidizing agent in microbial cell leading to the damage of bacterial cell walls (Lewis 2010; Randtke 2010; Mohammed 2019). After disinfection, bacteria reduced by 100% in the experimental well water with residual chlorine > 2 mg/L. The reduction in the bacterial pathogens (specific for faecal contamination) is on average greater for common germs (95%), total coliforms (91%), faecal enterococci (90%) than for *Escherichia coli* (85%) and sulphite reducing clostridia (67%).

Mohammed et al. (2020) showed that the use of $\text{Ca}(\text{OCl})_2$ disinfectant against isolated bacteria from drinking water supplies (tap and hand pump water) revealed the existence of bacterial resistance. Also, he highlights that the efficiency of calcium hypochlorite $\text{Ca}(\text{OCl})_2$ against *E. coli* and *S. kentucky* (not taken into account in this study) was 100% at a concentration of 0.5 mg/l and exposure time 120 min. For Li et al. (2013), both *Salmonella spp.* and *E. coli* are more resistant to

chlorine than both enterococci bacteria and total coliforms, where application of chlorine with a dose of 0.2–3.0 mg/L for 30 minutes led to reduction in coliform. According to (WHO)2017), the disinfection of drinking-water using chlorine has limitations against protozoan pathogens and high levels of turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria and give rise to a significant chlorine demand. An advantage of the chlorinator system in experimentation in the city of Cotonou is a continuous chlorination on the well water. Water quality assessment is an essential factor for improving the quality of water sources (Behailu et al. 2017) and ensuring the continuous supply of safe water in Cotonou and Lomé.

The need for integration and transformation of our local systems, technologies and cultural habits can complicate the implementation of SDGs at the local level (Schuthof et al. 2019). So, urban dwellers need relevant information on SDGs and social change. Field visits, use of videos, local language radio sections and infographic of information-education-communication (IEC) for behaviour change, environment and health



Figure 3. Septic tanks in plastic polyethylene at Ahouansori Towéta (a) ecological above-ground watertight pit latrine in swampy environment of Agla in Cotonou (b) and dry toilet in Lomé (c) (Photos: a,b) H.S. Totin Vodounon, August 2019; c) Koffi T., February 2021).



Figure 4. Chlorinator (hypochlorite of calcium) implanted in the experimental wells in Cotonou (Photos: a) H.S. Totin Vodounon, January 2020.

education helped to achieve this goal. Pathways of change on WASH knowledge and groundwater quality improvement and accessibility has been developed and promoted in Cotonou and Lomé. According to Acharya et al. (2020), IEC is not only limited to the process of changing behaviour but also a process of political, social, and economic transformation. The IEC approach used in the two cities aimed at contributing to the achievement of SDGs. Adequate IEC approaches can encourage and support follow-up for positive behaviour change (Mundorf et al. 2018), creates awareness, increases knowledge, changes attitude, and moves people towards change and continues their behaviours to adopt an innovation (WHO 2001). On the other hand, trainings have been given to the WASH business interest groups acting in Cotonou and Lomé to improve their mode of service delivery and create sanitation chain value. For Glass and Newig (2019), the decision-making process, implementation and acceptance of policies directed towards the achievement of sustainable development seem to be facilitated by both participatory and democratic governance structures.

A better mapping of the relationships between the goals is becoming increasingly relevant both in the academic (Nilsson et al. 2016) and political arenas (United Nations 2015). Based on the scientific results, policy briefs on integrated sanitation, hygiene and integrated groundwater management are developed to support Benin and Togo government

priorities on SDGs. Application of recommendations on the policy documents is also a pathway for SDGs achievement.

Status of knowledge on WASH and health risks, socio-ecological mechanisms and evidence of contribution to the achievement of SDGs 3, 6 and 11 in Cotonou and Lomé by two LIRA2030 Africa projects, aided in the development of an Ecohealth model for coastal cities in West Africa.

Ecohealth model for WASH and public health in Cotonou and Lomé

Ecohealth refers to the fact that people's health depends on the health of the ecosystem (Charron 2011). Ecohealth approach is useful for exploring health consequences of environmental degradation (Asakura et al. 2015). In this study, it is adapted as a model to solve public health problems related to groundwater deterioration due to unsafe sanitation and improper hygiene in Cotonou and Lomé (Figure 5).

As the city is facing numerous environmental problems, such as water pollution (Schuthof et al. 2019), an ecosystem approach can lead to its sustainability. In the ecosystem approach to public health, the urban environment is characterized as an ecosystem largely influenced by citizen's behaviours on sanitation. Conceptualizing human health from an Ecohealth perspective enables us to recognize that human health

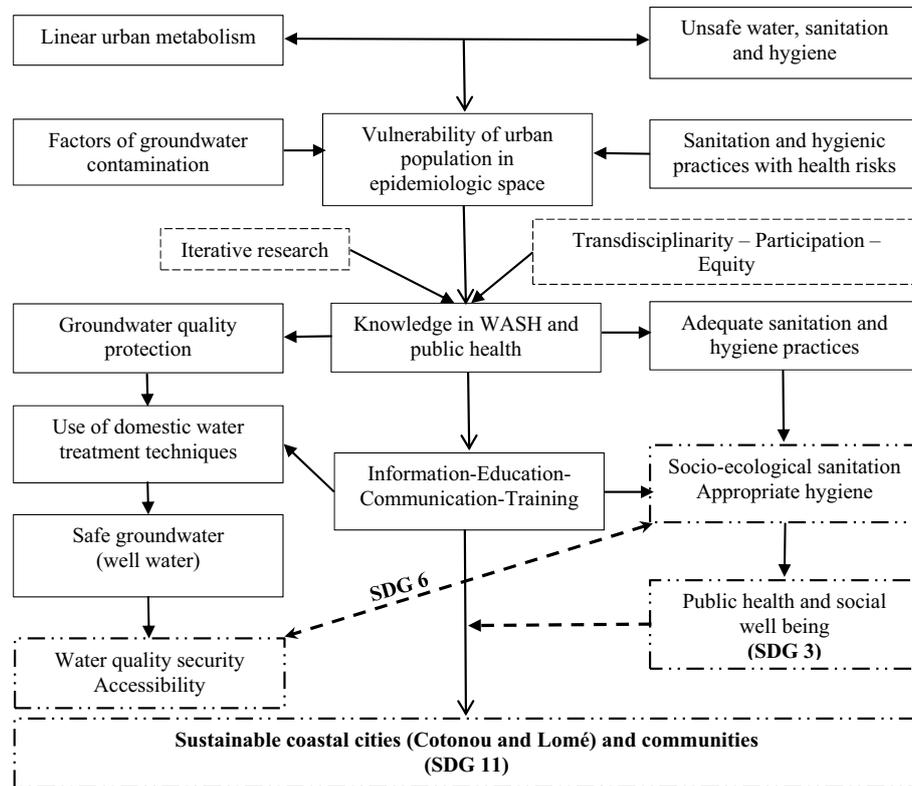


Figure 5. Ecohealth model for coastal cities in West Africa.

and well-being depend on the healthy functioning of ecosystems (Sy et al. 2014). These ecosystems also include aquifers, and water supply in Cotonou and Lomé. So in relation to SDGs 3 and 6, this means groundwater reservoir (providing well water) protection through ecological sanitation or the development of water treatment techniques.

The development of the ecosystem approach to health is in alignment with the transdisciplinary approach with an interest in the issue of gender and equity. From its conception, this research involved beneficiaries and key actors at the local level (political decision-makers and based-communities). During the implementation of the projects, information, communication and awareness raising were the main tools used in engaging stakeholders. Hence, the Ecohealth model was developed for the cities of Cotonou and Lomé to reduce health risks related to water, sanitation and basic hygiene. To this end, health risk practices were identified in order to develop an educational and awareness strategy on sanitation and hygiene to enable a shift in behaviour. The Ecohealth model responds to the concerns of public health improvement through integrated sanitation and hygiene and sustainable groundwater management.

The Ecohealth model is developed for West African coastal cities, based on a data set from Cotonou and Lomé. Thus, referring to knowledge on public health (current and expected status), the model Ecohealth is generated by establishing a relationship between

aquifers (hydrosystem) and sanitation and hygiene systems (disposal). In this regard, the status of the quality of coastal groundwater is correlated with unsafe sanitation and hygiene to help evaluate linked health risks.

The three pillars of the Ecohealth model (transdisciplinarity, participation and equity) lead to an effective and efficient translation of scientific knowledge into action (Barkin and Schlundt 2011), as in the cities of Cotonou and Lomé. Indeed, a multi-stakeholder approach helps to highlight health determinants (sanitation, hygiene, water-borne diseases) and conditions related to the ecosystem (groundwater quality deterioration). A consensus on validating the best adaptable socio-ecological system for sanitation practices, low-cost water treatment techniques, social acceptability and prospects (scenarios) for the coastal areas of Cotonou and Lomé was reached in the framework of participative field works and workshops on groundwater quality security.

In the application of the Ecohealth model, equity is realized by the role distribution of men and women involved in the actions. In this regard, women played a key role in the activities of behavior change and provided sensitization on acceptable, affordable, adaptable and manageable disposal options to improve and protect groundwater quality. However, Houéto et al. (2019) advise that without social inequalities in health reduction, achieving sustainable improvement results is almost impossible.

Conclusion

Based on the analysis of a complex social-environmental context and the evidence from the cities of Cotonou and Lomé, West African coastal cities are characterized (based on the implementation of SDGs 3, 6 and 11) by unsafe sanitation and hygiene which causes deterioration of groundwater quality. Results of our study indicate the presence of bacteria in sampled well water in the two cities and groundwater pollution. Water quality, sanitation and hygiene problems in these complex cities pose major health risks to the population, due to higher exposure.

Our interventions included improvement of sanitation and hygiene facilities, promotion of low cost well water treatment (continuous chlorination by calcium hypochlorite, use of Aquatabs water purification tablets, water ebullition), wastewater treatment (using phyto-remediation techniques), increase in the accessibility and water supply and the use of education-information-communication for social change in the two cities.

The information gathered from the study aided in the development and implementation of an Ecohealth model to help ensure proper sanitation and good hygienic practices in West African cities towards improving the quality of well water for public health protection and for building sustainable coastal cities. The adoption of integrated water, sanitation and health management and the implementation of the Ecohealth model together with constant education on environmental issues in relation to health will help sustain West African coastal cities and contribute to the progressive achievement of the SDGs.

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