

Research Paper

Response to COVID-19: building resilience through water and wastewater management in Ghana

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ABSTRACT

This study assessed the effects of COVID-19 on Ghana's WASH system. It focused on low-income households and WASH sector stakeholders using Ayawaso East Municipality as a case study to document lessons from the pandemic's impact on the WASH sector. We used the water and sanitation system approach to understand the effects of COVID-19 mitigation measures on the WASH system. Data were collected through surveys, stakeholder engagements, and document analysis. We found that the government's WASH response increased hygiene practices, solid and liquid waste generation, and water consumption. Sanitation service providers experienced reduced demands for their services, lost clients, and increased operational expenditure. The pandemic's impact is gendered, with women and girls experiencing a greater burden. We argue that responses to the pandemic highlight the need and opportunities for sustainable management of sanitation waste through integrated, circular economy business models, turning waste into valuable resources. Responses to COVID-19 in the WASH system are multisectoral because of its interconnected nature, highlighting the need to integrate sectors beyond water and sanitation. This requires improved institutional structures, policies, investment, and professionalising service providers.

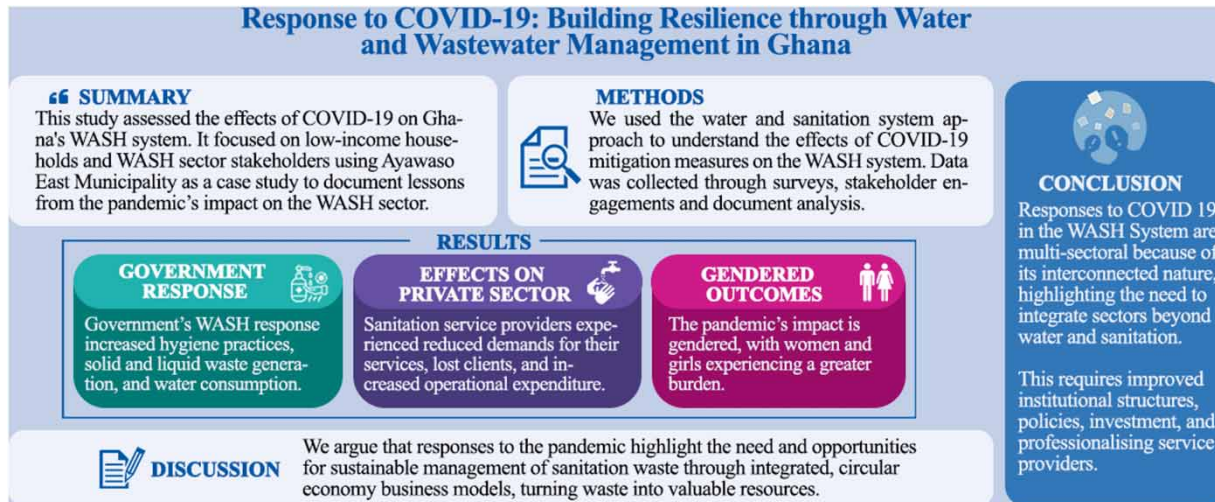
Key words: COVID-19, Ghana, hygiene, sanitation, wastewater, water

HIGHLIGHTS

- Government's WASH response to COVID-19 increased hygiene practices.
- A holistic approach to managing all aspects of WASH is vital.
- Effective COVID-19 responses require effective inter-agency cooperation.
- Social inclusion and support to marginalised groups is critical to deal with a pandemic.
- Investments along the whole service delivery chain are needed to improve wastewater management.

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GRAPHICAL ABSTRACT



INTRODUCTION

In November 2019, an outbreak of COVID-19 was reported in Wuhan, China (El-Baz *et al.* 2020). The virus began spreading rapidly worldwide, and by March 2020, the WHO declared it a global pandemic (World Health Organization 2020). Ghana reported its index case on 12 March 2020 (Ministry of Health 2020). In response, the government initiated several steps, including an inter-ministerial task force to prepare a response plan. An Emergency Operations Centre, set up under the auspices of the Ghana Health Service at the beginning of 2020, was activated (Ministry of Health 2020). To limit the spread of COVID-19, restrictions on movement were implemented, including a 3-week lockdown in Accra, Kumasi, and other major urban areas with the highest number of reported cases (Tagoe *et al.* 2022). All external borders were closed, schools were shut, and a ban was placed on all public gatherings (such as religious activities, funerals, conferences, and festivals) (IRC International Water and Sanitation Centre 2020) to curtail the spread of the virus (Figure 1).

The government's COVID-19 containment measures resulted in diverse impacts on the economy and livelihoods of many Ghanaians (Statistical Service Ghana 2020; Aduhene & Osei-Assibey 2021; Bukari *et al.* 2021). Interventions, including providing free water services to promote handwashing and hygiene, were initiated to mitigate the social and economic impacts of the pandemic. The government's WASH response was against a backdrop of uneven access to WASH services. Figure 2 shows that less than half of Ghanaians (45%) access basic drinking water services while only 36% access safely managed drinking water services. Access is more limited in rural areas where only 11% access safely managed drinking water services compared to 57% in urban areas. More than half (60%) of urban residents access limited sanitation services. Almost one in every five Ghanaians practice open defecation. The practice is more prevalent in rural areas (31%) compared to urban areas (7%). These figures, particularly the lack of safely managed sanitation, highlight the limited access to adequate sanitation facilities, safe treatment, and disposal of liquid and solid waste nationally.

While the government's WASH interventions associated with the COVID-19 response were timely and critical, there is limited empirical data on their effects on the water and sanitation system. The study assessed the pressures, drivers, and responses to the pandemic by investigating how the outbreak affected the WASH sector using Ayawaso East Municipality as a case study. The Ayawaso East Municipal Assembly is one of the 29 Metropolitan, Municipal and District Assemblies (MMDAs) in the Greater Accra Region of Ghana. It was carved out of the then Accra Metropolitan Assembly in 2018. The municipality is densely populated, with a population of around 130,256 (Ministry of Finance 2019). While not representative of Ghana, particularly considering rural-urban dynamics, Ayawaso East Municipal Assembly is emblematic of Ghana's WASH challenges. We draw lessons for the country's WASH sector using this case study.

MATERIALS AND METHODS

We adopted a mixed-methods approach comprising 165 household surveys, 8 Focus Group Discussions, key informant interviews, and document analysis to enable a robust understanding of COVID-19 impacts on the WASH sector and options for

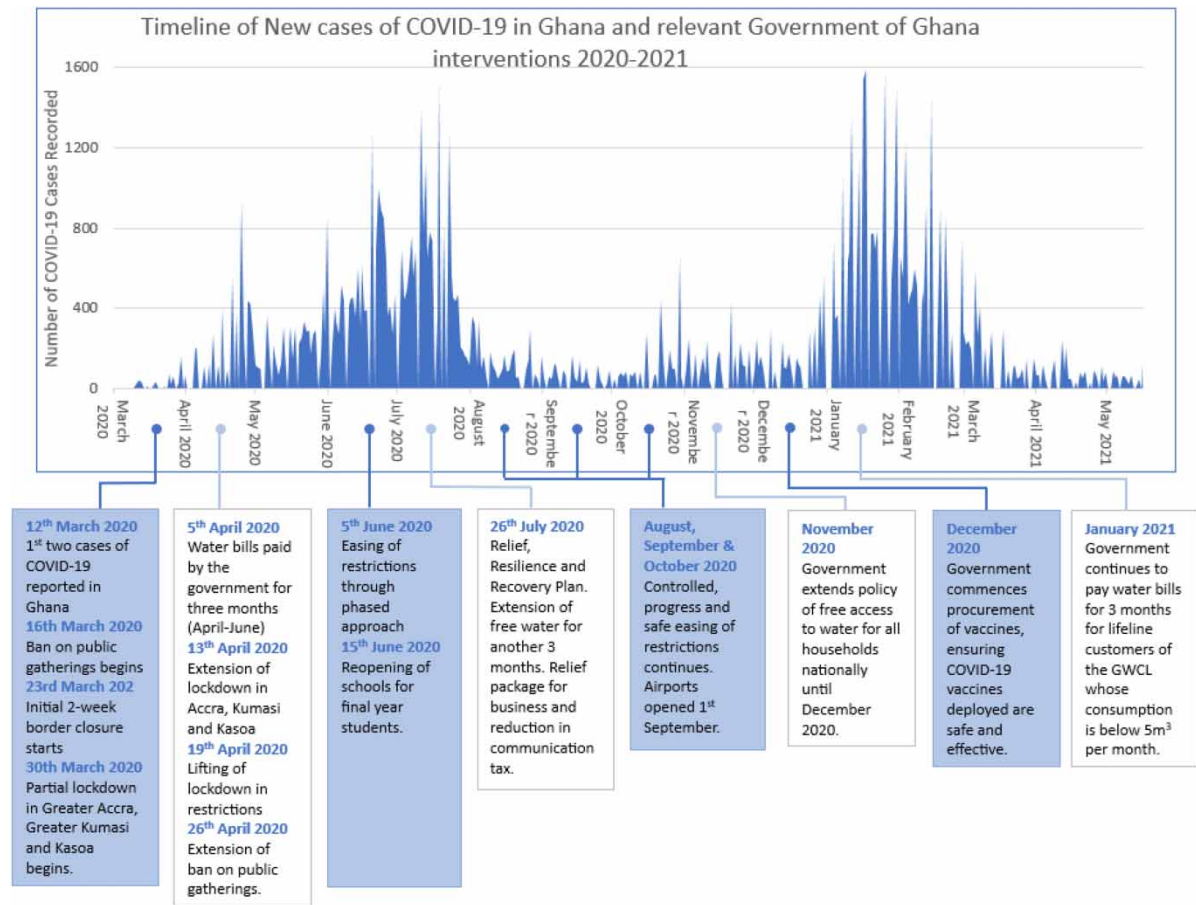


Figure 1 | Timeline of daily COVID-19 infections and Government interventions in Ghana. *Source:* Authors' construction based on information from Presidential addresses and data from <https://ourworldindata.org/coronavirus-data>.

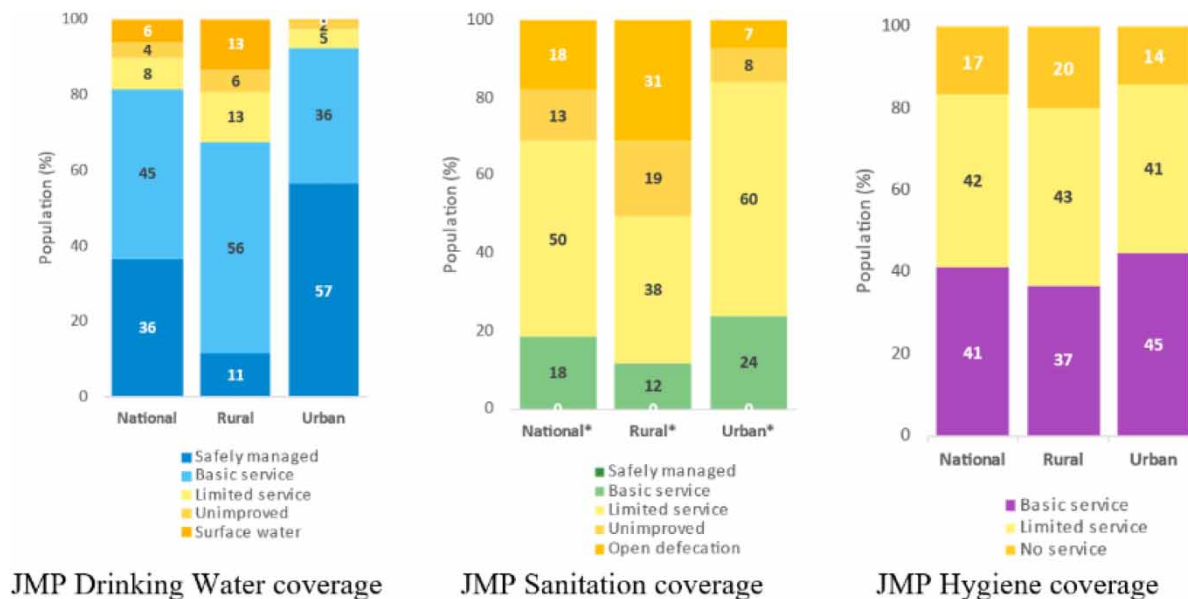


Figure 2 | Illustrates the state of WASH services in terms of access based on data from the WHO/UNICEF Joint Monitoring Programme (JMP). *Source:* WHO/UNICEF/JMP (2019) and <https://washdata.org/>.

building resilience. The study participants were selected purposively. The study focused on the water and sanitation system (the ‘system’) because of a limited understanding of the effects of COVID-19 mitigation measures on it. ‘WASH system’ refers to the stakeholders, organisations, and institutions involved in WASH. [Huston & Moriarty \(2018\)](#) presented a set of building blocks for WASH systems, namely, institutions, policy and legislation, finance, regulation and accountability, monitoring, planning, infrastructure, water resource management, and learning, and adaptation. A systems approach to reviewing the COVID response considered key stakeholders interested in WASH – actors who affect or are affected by actions in the system. The study reviewed stakeholder roles and mandates, and the policies, strategies, and regulations that guide their actions, particularly concerning their COVID-19 responses. The study also considered the capabilities of sector actors to act on, and respond to changes brought about by COVID-19. The actions and interactions among stakeholders during COVID-19 were reviewed. Beyond this, the study considered the impact of the pandemic on WASH infrastructure and service delivery. These were all analysed within the context of the project’s conceptual framework: The ‘Driver-Pressure-State-Impact-Response’ (DPSIR) framework.¹ The framework was adapted by including recovery and resilience for ‘building back better’ (BBB). The resulting conceptual framework consists of 4Rs (Response, Risk, Recovery, and Resilience), as illustrated in [Figure 3](#).

The response was analysed first by unravelling the drivers, pressures, and state of service provision of the core components of the system, pre-COVID-19, and how different categories of actors responded. Risk involves analysing the outcomes and impacts of responses concerning actors’ vulnerability (gender, income, age, system access inequalities). Insights were synthesised to identify recovery mechanisms and solutions to address negative outcomes. Diverse recovery processes and solutions were analysed and proposed to stakeholders at different governance levels through appropriate engagement

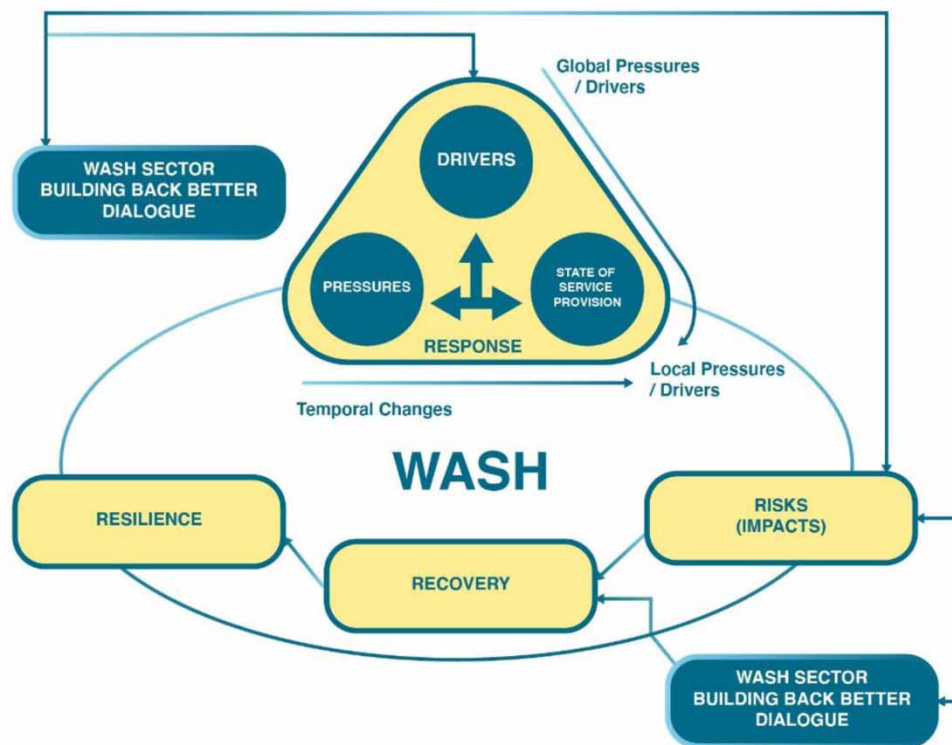


Figure 3 | Project conceptual framework. *Source:* Authors’ construction adapted from DPSIR.

¹ DPSIR (drivers, pressures, state, impact, and response model of intervention) is a causal framework for describing the interactions between society and the environment. <https://commons.wikimedia.org/wiki/File:DPSIR.svg>.

processes, including the BBB policy dialogues.² These solutions help organisations, households, and individuals to build resilience, in the context of water and sanitation, during and after the pandemic. Finally, resilience building processes supported the evaluation of the recovery solutions generated and provided evidence within the BBB Dialogue to inform policymaking and practice at relevant ministries, as well as MMDAs, who are actors within the system. The framework (Figure 3) was used to address and integrate the four specific objectives through a multiple-pronged methodology and complementary studies, as outlined in Table 1. The study was grounded in respect and protection of the privacy of participants, voluntary participation, and informed consent. We ensured that participants were diverse, thus including the voices of all stakeholders. We also ensured that participants experienced no harm because of their participation in the study. The International Water Management Institutes' Institutional Review Board reviewed and approved the study protocol.

FINDINGS AND DISCUSSION

Stakeholders and their roles in the WASH sector

Table 2 presents an overview of the roles and mandates of major WASH stakeholders, together with their responses to COVID-19. Stakeholder roles and responsibilities are well-defined, and responses are relatively rapid. Appropriate enabling legislation was also in place to support service delivery. Although policy instruments were not specific to the pandemic, there were opportunities for adjustment and to prepare guidelines to carry out government directives relating to COVID-19. Most organisations also have well-defined visions and goals, articulated in policy documents, strategic action plans, or medium-term development plans. MMDAs are responsible for providing infrastructure and services at the municipality and district levels and overseeing sanitation and waste management services. Funds for services are provided by the central government, internally generated funds, and projects. Small-scale transportation of faecal sludge (FS) was by vacuum truck operators. Generally, vacuum truck operators belong to a trade association and have business permits to operate. Fees charged are determined based on distance, septic tank volume, and client type. The Ghana Water Company Limited (GWCL) and the Community Water and Sanitation Agency (CWSA) provide water services for urban and rural areas. The public pays for service operation and maintenance through a billing system, and in rural areas through direct sales at standpipes and water points.

Response: Pressures, drivers, and responses to COVID-19 in Ghana – the case of Ayawaso East Municipality

In response to the pandemic, the government declared free water provision for an initial period of 3 months, later extended to 9 months (March to December 2020) for the general populace (Morgan 2020), and an additional 3 months (January to March 2021) for low-income households consuming less than 5 m³ of water per month. This resulted in a significant increase in water consumption. The GWCL increased water supply by more than 42% and provided more public standpipes, polytanks, and tanker services to meet the demand. Household survey in Ayawaso East showed that around 55% of respondents had access to free water, and water consumption increased by around 37%. The survey indicated that providing handwashing facilities to combat the spread of COVID-19 led to an increase in handwashing throughout Ayawaso East. This finding is consistent with a USAID-funded study on the impacts of COVID-19 in Ghana which documented an increase in handwashing (Tetra Tec 2021).

Increased use of PPE, sanitisers, handwashing, and enhanced hygiene practices contributed to increased solid and liquid waste generation and a decrease in the quality of wastewater. The characterisation of wastewater from handwashing stations in Accra and wastewater treatment plants in Kumasi by this study recorded higher levels of both total solids and chemical oxygen demand (COD) than before the pandemic. Issues such as absenteeism and inadequate supply chains affected the sustainable operation of wastewater treatment plants. The three hospitals included in the study recorded a 3–7-fold increase in medical waste generated because of PPE use as protection against COVID-19. The proportion of highly infectious pathological waste incinerated on-site also increased. This is consistent with other reports that have linked health responses to the pandemic with increased medical waste and concerns about managing such waste (Tsukiji *et al.* 2020; Andeobu *et al.* 2022; World Health Organization 2022).

² A series of stakeholder dialogues was held as part of the study to identify the risks and responses as well as learn from the impacts of the pandemic on the WASH sector, including low-income households, service providers, and public sector organisations. The dialogues aimed to provide policy recommendations for recovery from the pandemic, and offer recommendations for supporting vulnerable groups to recover livelihoods.

Table 1 | Study objectives and methodologies

Component	Objective	Methodologies employed
The System	Define the WASH system.	<ul style="list-style-type: none"> Review and analysis of the WASH landscape identifying key stakeholders (national and local government entities, public sector agencies, private sector companies, NGOs, and umbrella organisations) and their mandates, roles, and capacities to respond to the pandemic.
Pressures	Assess pressures, drivers, and responses to COVID-19 in Ghana in terms of water demand and consumption, and wastewater generated.	<ul style="list-style-type: none"> Ayawaso East Municipality case study in Accra involved surveying heads of 165 households to gain insights from impacted communities. This municipality was selected because of being an early hotspot of COVID-19 in Ghana. The study aimed to understand actual water demands and consumption, wastewater generation, and the pressures driving these from a COVID-19 impacted group. Qualitative study using eight Focus Group Discussions (FGDs) disaggregated by women, men, youth, and mixed groups; key informant interviews (hospital management staff).
Risks	Assess risks and vulnerability among social groups and organisations due to adapting to COVID-19 and calls for improved WASH practices.	<ul style="list-style-type: none"> Analysis of household survey responses and FGDs with community members in Ayawaso East Municipality. Analysis of responses from hospital surveys. Sampling and characterisation of wastewater from handwashing stations in Accra and wastewater treatment plants in Kumasi. Analysis of responses to the survey of special groups, such as vacuum tanker drivers involved in transporting faecal sludge. Key informant interviews with representatives of 10 stakeholder organisations involved in WASH (Table 2).
Recovery and Resilience	Identify and analyse short-term solutions to facilitate the recovery of targeted communities from the pandemic. Apply a circular economy approach to build resilience among the multiple sectors and actors to COVID-19 pandemic shocks, along the water and sanitation service chains.	<ul style="list-style-type: none"> Surveys and key informant interviews provided information on coping mechanisms and actions towards recovery that WASH sector stakeholders adopted. Review and analysis of data collected from targeted communities, social groups, and organisations along the sanitation service delivery chain.
	Engage in dialogue with sector stakeholders. Provide policy and practice recommendations to enhance WASH systems' inclusiveness and resilience towards COVID-19-related risks.	Stakeholders were engaged through interviews and a series of BBB Policy Dialogues. Four such dialogues took place: (1) project kickstart meeting, (2) WASH-DP engagement meeting, (3) stakeholder meeting on Environmental Surveillance of COVID-19 in Ghana, and (4) final BBB dialogue to share results of the research. More than 60 participants were engaged in the various stakeholder dialogues.

Risks and vulnerability among social groups and organisations as a result of responses to COVID-19

COVID-19 in Ayawaso East Municipality affects women, men, youth,³ and children differently, with women and girls facing a higher burden. Women and girls are generally burdened with collecting water for households, a task which became more demanding because of the additional water needed for COVID-19 hygiene practices such as handwashing. A study by

³ A youth is someone aged 18–35 (Ministry of Youth and Sports National Youth Authority).

Table 2 | WASH sector stakeholders' roles and response to COVID-19

Mandate	Institution Responsible	Response to COVID-19
Policy, planning, budgeting (sector leadership and coordination)	<ul style="list-style-type: none"> Ministry of Sanitation and Water Resources (MSWR) – lead Ministry of Health Ministry of Local Government and Rural Development Ministry of Environment Science, Technology and Innovation Ministry of Education National Development Planning Commission 	<ul style="list-style-type: none"> MSWR coordinated action of government directives on WASH. Ministry of Health led government health-related responses to COVID-19. The Ministries of Local Government and Rural Development; Environment Science, Technology and Innovation; and Education and the National Development Planning Commission supported the planning and execution of COVID-19 measures.
Financing	<ul style="list-style-type: none"> Ministry of Finance (MoF) Development partners (World Bank, African Development Bank, United Nations Children's Fund (UNICEF), Netherlands Embassy, United States Agency for International Development (USAID)) Private sector – financial institutions 	<ul style="list-style-type: none"> MoF provided financing to support government interventions, with support from external agencies and development partners. Development partners. Local financial institutions provided relief to clients.
Regulation	<ul style="list-style-type: none"> Water Resources Commission Environmental Protection Agency Metropolitan, Municipal and District Assemblies (MMDAs) 	<ul style="list-style-type: none"> As part of their regulatory role, MMDAs ensured that COVID-19 protocols were observed in public places, particularly markets. The Environmental Protection Agency supported the planning and execution of COVID-19 measures.
Service development and provision (operational and implementation levels)	<ul style="list-style-type: none"> Ghana Water Company Limited (GWCL) – urban water Community Water and Sanitation Agency (CWSA) – rural WASH MMDAs 	<ul style="list-style-type: none"> GWCL and CWSA provided free water services. CWSA coordinated the activities of WASH NGOs and service providers in rural areas. MMDAs provided handwashing facilities and undertook public cleansing and fumigation activities.
Service providers (sanitation service delivery chain from containment facilities through to transport and treatment)	<ul style="list-style-type: none"> Local Assembly (sewerage, public toilets) Private sector companies (large- and small-scale, formal and informal service providers) Local artisans; landlords 	Service provision, clean up. Small-scale tanker services provide emptying and transport services to households, public toilets. and institutions.
Beneficiaries	Community – households, institutions	
Local and international NGOs	UNICEF, Environmental Service Providers Association (ESPA), Coalition of NGOs in water and sanitation (CONIWAS) members (e.g., Water and Sanitation for the Urban Poor (WSUP), WaterAid, SNV, Global Communities, Plan))	Provision of WASH facilities, Personal protective equipment (PPE), public education, mobilisation of members
Research and training institutions	Council for Scientific and Industrial Research-Water Research Institute (CSIR-WRI), IWMI, Kwame Nkrumah University of Science and Technology (KNUST), University of Ghana, University of Energy and Natural Resources (UENR), etc.	Research

Bukari *et al.* (2021) found that the impacts of COVID-19 in Ghana were different across genders, with male-headed households able to cope better than female-headed households. More women are self-employed, or are in informal employment, with lower earnings than men. Losing these informal jobs greatly impacted them. Furthermore, the role of women as caretakers, when children had to stay home because of school closure, prevented some from engaging in business activities during the lockdown (Badri 2020).

COVID-19 affected youth in the municipality through loss of employment and disruption of schooling following school closures. About 40–45% (Figure 4) of youth surveyed faced unemployment resulting from COVID-19, worsening already high unemployment rates. The impact of job losses on adults was also significant. About 66% of men and 60% of women lost jobs, mostly among those in informal businesses or in self-employment (Figure 5). Bukari *et al.* (2022) found a strong link between COVID-19 and income shortages due to unemployment, finding that 61% of households had often gone without sufficient income. The poverty levels of households whose heads were unemployed due to COVID-19 increased significantly (56%), while living standards decreased by around 66%.

In a country where some households spend up to 80% of their income on food (Bukari *et al.* 2022), the loss of income coupled with increased food prices during the pandemic posed a significant threat to food security. Loss of income affected the purchasing power of those relying on informal opportunities. In Ayawaso East, where residents depend largely on informal employment, the economic impacts of the pandemic were significant. According to the household survey, 16% of males and 21% of females did not have sufficient food in the month before being interviewed, yet Government food assistance only reached 4% of males and 10% of females. Bukari *et al.* (2022) found a statistically significant association between COVID-19 and food insufficiency across 10 regions in Ghana. More than half (58%) of the households interviewed in that study reported going without sufficient food several times due to the pandemic. Schotte *et al.* (2021) also found that the pandemic and lockdown impact in Ghana were mostly felt by self-employed and informal sector workers.

Access to sanitation was a challenge before COVID-19 (see Figure 1). Ninety percent of respondents shared toilet facilities with other households, potentially exposing them to COVID-19. A study by Caruso & Freeman (2020) suggests that shared facilities could become sources of airborne and contact exposure to COVID-19, especially without adequate water and soap for hygiene purposes. Although SARS-CoV-2 has been detected in feces and remains viable for days on stainless steel and plastic surfaces – materials used for doors and other high-contact surfaces in toilets and latrines – these are not major

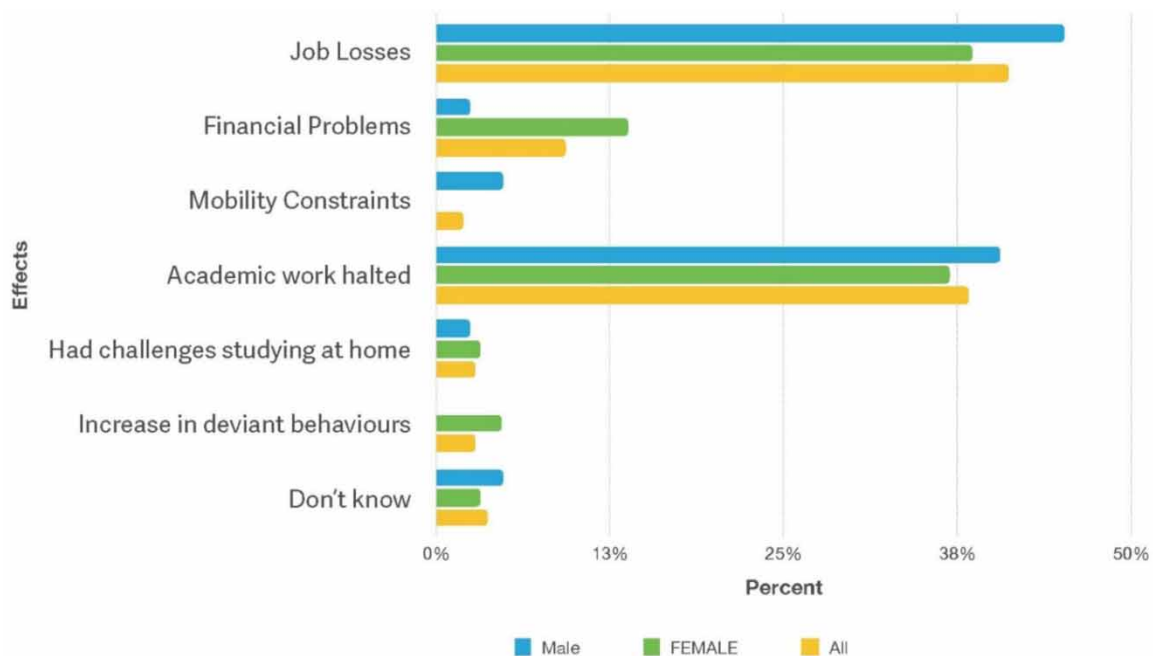


Figure 4 | The impact of COVID-19 on youth in Ayawaso East Municipality.

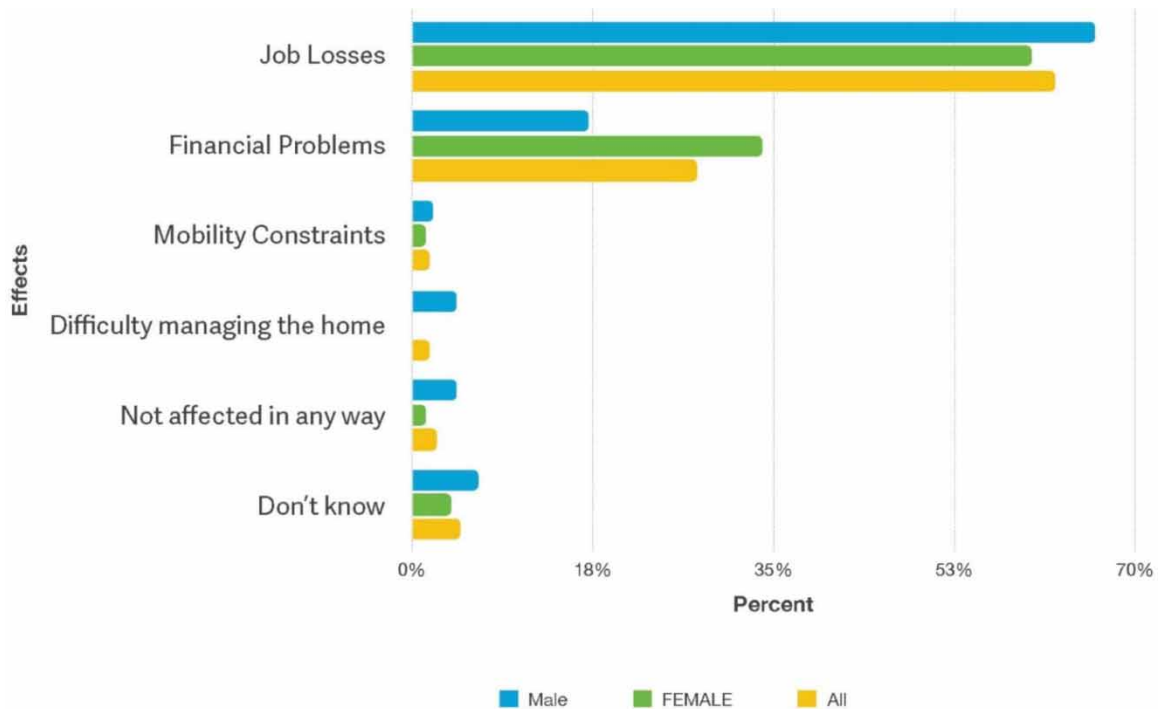


Figure 5 | Impact of COVID-19 in Ayawaso East Municipality, Greater Accra.

transmission routes (Lewis 2021) and faecal-oral transmission is a highly unlikely route for SARS-CoV-2 transmission (WHO 2020; Cerrada-Romero *et al.* 2022). Although urban and peri-urban farmers in Ghana use wastewater diluted with water from other sources to grow vegetables, transmission risks via the food chain through wastewater irrigation remain very low (Haji *et al.* 2021). Thus, perceptions of risks concerning reuse and recycling of wastewater and FS may be far higher than reality. Adopting a holistic approach to assess the various contaminants and associated risks of wastewater reuse and recycling is crucial because SARS-CoV-2 is not the only contaminant of concern.

Beyond access to water and sanitation, other dimensions of lack of inclusiveness were observed. Waste management workers, for instance, did not receive government support because they were not considered frontline workers. In the three hospitals studied, COVID-19 risk remuneration eligibility did not extend to waste workers despite them facing a higher risk of contracting COVID-19. One respondent reported that medical waste handling staff were 'left behind' despite being at risk of contracting COVID-19 infection. As Andeobu *et al.* (2022) noted, improper handling of medical waste could lead to secondary infection of waste handlers.

The risk to businesses along the sanitation value chain is another pandemic impact. Sanitation service providers (vacuum truck operators) faced reductions in the number of clients served, service fees charged, and increased police hostility during the lockdown. Vacuum truck operators are essential in Ghana's sanitation service delivery chain, providing FS transport to treatment facilities. The closure of schools and business premises resulted in reduced demand for their services. The number of clients served during COVID-19 decreased by 20% for households, 24% for public toilets, and 29% for private institutions. Fees charged for services were reduced by 19% across all clients. Tanker service providers lacked adequate coping mechanisms and did not benefit from government interventions. Only 16% of those surveyed received training from local public sector agencies regarding safe and effective service delivery during the pandemic. For larger, private service providers, the pandemic reduced revenue and loss of clients (mainly for waste management companies) by 25–40%. There was also a corresponding increase in operational expenditure. One company reported a 10% increase in operational costs from providing PPE for staff and running a shift system to reduce staff numbers on duty at any one time.

Public sector agencies focused on delivering government directives and interventions on free water services, by pre-financing the delivery of free water and then billing the government. However, water vendors, who did not get free water,

continued to charge residents despite warnings from MSWR, because this is their source of income. Investment in expanding services, asset rehabilitation, and other capital expenditures were affected as operations were re-adjusted to free funds for water service delivery. Due to bureaucratic processes and billing times, government payments were sometimes delayed, reducing operational revenues and system inefficiencies. For example, in Chirapatre (Kumasi), erratic and inadequate water supplies were reported during the free water period (personal communication).

For MMDAs, lockdown meant reduced revenues from markets and central business districts. Key informant interviews revealed that some MMDAs reported revenue reductions equivalent to achieving only 60–70% of their 2020 targets. For the country, the Ghana Revenue Authority reported ‘a reduction of revenue targets for and the petroleum and manufacturing sectors from GH¢47 billion to GH¢42 billion and US\$1.57 billion to US\$660 million, respectively’ (Ghana Center for Democratic Development 2021). Financial transfers from the central government were reallocated to the COVID-19 response. Despite these impacts, the pandemic provided opportunities for MMDAs to collaborate with sector ministries to improve WASH in public places. MMDAs in Accra in collaboration with the Ministry of Local Government provided handwashing facilities and fumigated markets. Others worked with the Ministry of Sanitation and security agencies, and organised clean-up activities of public places. MMDA waste management departments interviewed highlighted the need to consider health-care waste management as part of the pandemic response.

Recovery: Short-term solutions that facilitate recovery from COVID-19, building resilience to pandemic-type shocks

Household surveys documented short-term measures, including staying at home (36% of men, 21% of women) to protect themselves against COVID-19. More men than women reported taking other protective measures, including frequent handwashing, practising social distancing, and avoiding handshakes or touching their mouth and eyes. This contrasts with a study in Indonesia which found higher compliance with COVID-19 prevention measures among females (Paramita *et al.* 2021). In Ghana, the difference could be attributed to women being largely responsible for domestic chores and food provision, which requires them to go to markets where COVID-19 restrictions were not strictly observed.

According to interview responses, households were highly dependent on purchased sachet water⁴ to meet their drinking water needs in the short term. The GWCL monitored the provision of free services and increased tanker service frequency where needed. Customers could call the national helpline to provide information on where water was needed so the company could respond. The government also paid some private tanker operators to ensure delivery to low-income areas. MMDAs provided innovative handwashing facilities, such as ‘veronica buckets’ (Ministry of Sanitation and Water Resources *n.d.*) in public places. Hand sanitisers, masks, and waste bins for safe disposal of tissues were provided at handwashing facilities. Additional polytanks and standpipes were provided in some low-income communities. For short-term management, Caruso & Freeman (2020) recommend that handwashing be provided at shared facilities, in addition to ensuring social distancing in queues. Solutions implemented by the Government of Ghana were similar to the short-term solutions recommended by the World Bank for low-income communities (Kotwa *et al.* 2020). However, these interventions, while providing temporal support to communities, are not sustainable over the long term and have since ceased.

The study highlighted the need for improved health and safety practices and operational regulations to ensure safe disposal of faecal sludge. A survey of 56 tank operators found that short-term operational measures and regulations, such as desludging FS at designated dumping sites and ensuring no leakages while providing client services, are important to ensure limited exposure to untreated waste (Figure 6). There is also a need for further dialogue and cooperation between operators and the local government, and a conscious move towards service professionalisation. Even though the use of PPE among waste workers increased during the pandemic, the type of PPE used varied, indicating that its use was subject to service providers’ knowledge and resources.

Learning from the country’s WASH response to the pandemic, the stakeholders recognised the value of building the resilience of the water and sanitation sector against future pandemics. In this study, participants identified improved waste management practices as an important component of a resilient water and sanitation sector that emerged from responding to the pandemic. Healthcare facilities improved waste management practices because of COVID-19. For example, some facilities that had previously burned medical waste in the open instituted plans to manage this waste more professionally. One

⁴ Sachet water, also known as ‘pure water’, is a name commonly used to refer to small plastic sachets or bags of water containing between 200 and 500 millilitres sold for consumption at low prices.

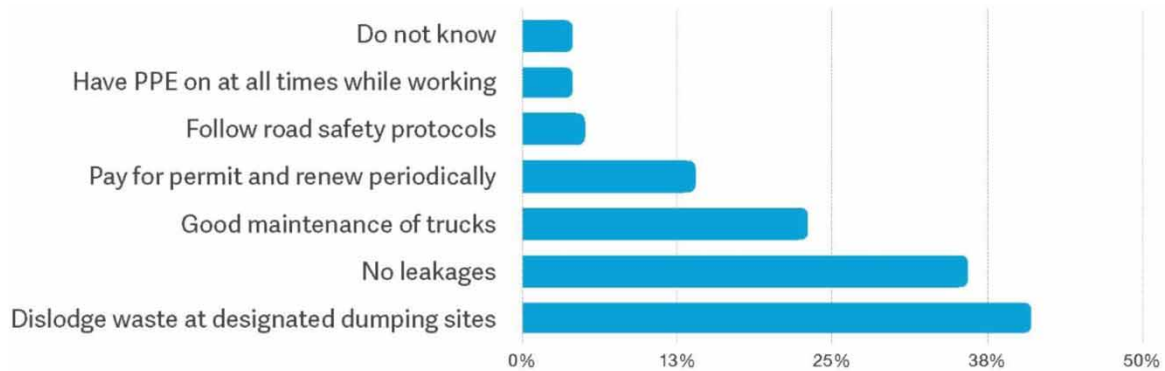


Figure 6 | Key operational regulations for vacuum trucks to follow from local authorities.

respondent reported that COVID-19 enhanced medical waste separation. Outsourcing waste management to private sector actors also increased the professionalisation of waste management. Collaborative approaches to providing water and sanitation services are another dimension of building the sector's resilience that emerged in response to the pandemic. MMDAs collaborated with the Ministries of Local Government, and Sanitation and Water Resources and security agencies to carry out clean-up activities and fumigation. WASH stakeholders also participated in the Emergency Operations Centre, set up under the auspices of the Ghana Health Service, which coordinated the country's response to the pandemic. Recognising the roles of private sector actors in delivering WASH services, engagement with stakeholders such as water tank vendors and vacuum operators was enhanced to improve WASH services. Experiences from such collaborations provide valuable lessons for institutional arrangements in responding to the pandemic.

Resilience: Recommendations to enhance the inclusiveness and resilience of WASH systems to COVID-19-related risks

Stakeholder engagement provides an understanding of requirements from multiple perspectives, ensuring actual needs and challenges are identified and analysed. This helps generate policy and practice insights and recommendations, leading to more inclusive WASH systems that can withstand COVID-19, other pandemics, and related risks. Dialogue provides opportunities for research insights to be shared with stakeholders, while providing a space for them to openly brainstorm and collaboratively identify actions to support the process of BBB. Responses to COVID-19 are multisectoral, highlighting the need to better integrate sectors beyond water and sanitation.

Safe management of sanitation waste remains a pressing challenge in Ghana. However, there are circular economy opportunities for improved solid waste and wastewater management. Sustainable sanitation waste management can be achieved through integrated, circular economy business models that go beyond standard sanitation services, turning FS into valuable resources such as nutrients, organic matter, and energy. This is particularly pertinent to situations where public investment in sanitation is limited. Cost recovery strategies are needed to encourage more private sector investment, leading to enhanced service delivery. Shifting from waste treatment 'for disposal' to waste recycling 'for reuse' is one important option for cost recovery and business development along the service delivery chain. Effective FS management requires going beyond the provision of toilets to having efficient emptying and transport services, and proper treatment and reuse of FS. In Ghana, and many countries, where resources are scarce, the potential value of reusing this waste remains largely untapped (Sugihara 2020). Harnessing these opportunities could encourage further investment, especially by the private sector, to provide more sustainable waste management infrastructure and processes.

For institutions involved in delivering WASH services, adequate planning and preparation of responses for emergencies, such as COVID-19, provide opportunities for resilience building. Plans should balance longer-term vision and strategies with the need to shift focus and implement rapid, emergency actions. This will ensure that service provision in the longer term is less likely to be affected because institutions will be better prepared to continue to undertake capital expansion and operation and maintenance while increasing service provision.

A review of COVID-19 WASH response in 84 countries found a range of responses across the countries. The review found that in sub-Saharan Africa, responses to the pandemic targeted hygiene promotion and other infection prevention and control

measures (Giné-Garriga *et al.* 2021). Ghana's WASH sector response to the pandemic is consistent with other SSA countries. It targeted hygiene promotion, prevention, and infection control. As shown in Figure 7, Ghana is one of the countries in SSA with the most interventions (Giné-Garriga *et al.* 2021). The interventions include the provision of handwashing stations and soap at public WASH facilities. However, the review found limited evidence of technical and financial support to WASH utilities and WASH service providers (Giné-Garriga *et al.* 2021).

CONCLUSIONS AND RECOMMENDATIONS

This study assessed and documented lessons from the impact of the COVID-19 response on Ghana's WASH sector and contributed to BBB. The study's findings revealed that WASH stakeholders collaborated in providing short-term responses to the pandemic. However, these short-term responses require balancing short-term with longer-term vision and strategies with the need to shift focus and implement inclusive and gender-response sustainable WASH interventions. Wastewater management

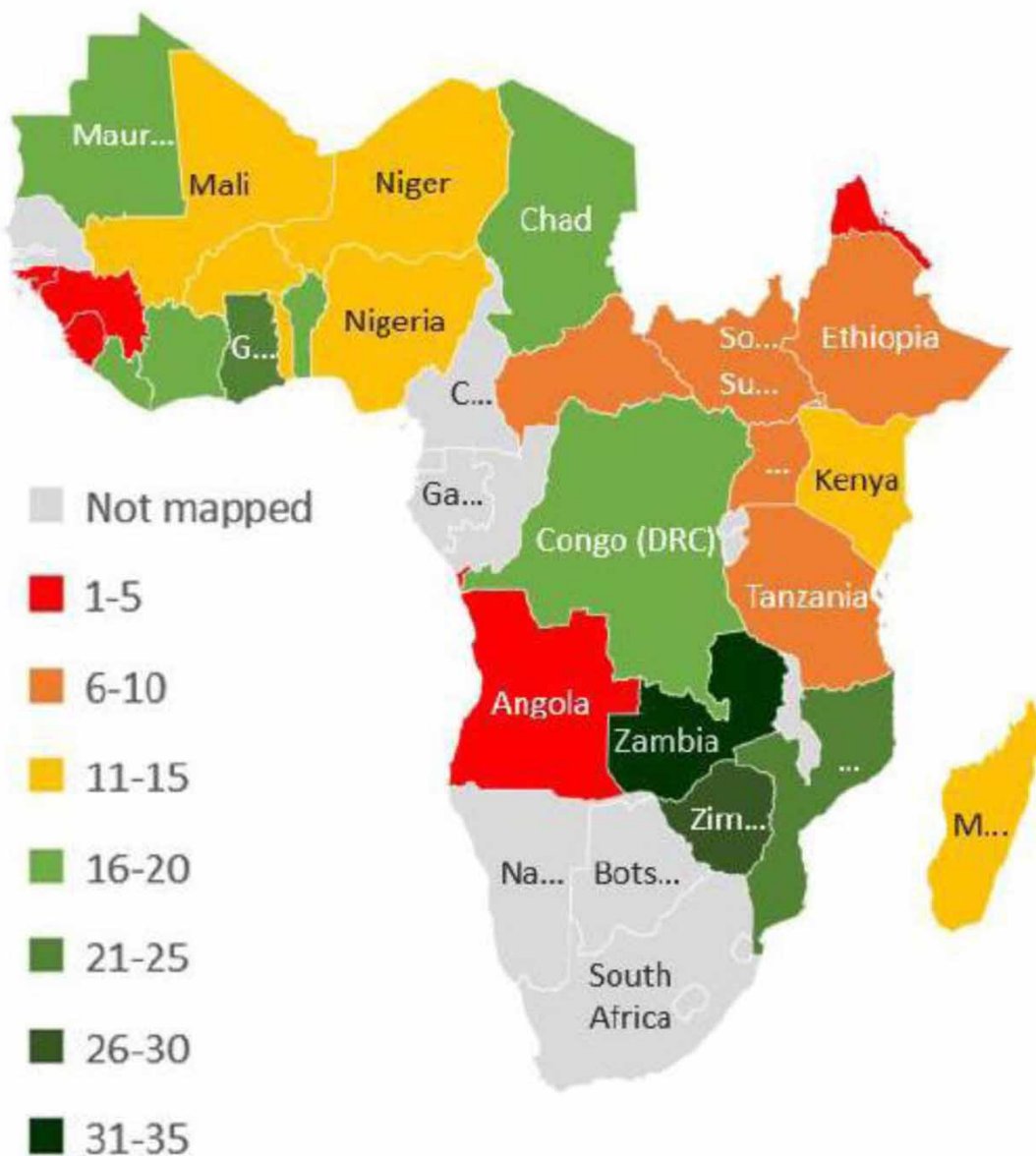


Figure 7 | Regional map of sub-Saharan Africa showing the total number of measures – 1 May 2020. *Source:* Stockholm International Water Institute (2020).

policies need to be updated in response to COVID-19 and future pandemics. Investments along the service delivery chain are needed to improve wastewater management. Adopting circular economy practices along the sanitation service chain can reduce costs and incentivise increased private sector investment. Losses by vacuum tank operators could be offset through training that enables them to benefit from government support while also improving occupational health and safety. Expanding infrastructure to deliver services is a key component of developing the WASH system. The WASH sector is interconnected with other sectors and adopting a holistic approach will enhance its sustainability. Responses to COVID-19 highlighted the need for inter-agency cooperation.

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DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

- Aduhene, D. T. & Osei-Assibey, E. 2021 *Socio-economic impact of COVID-19 on Ghana's economy: challenges and prospects*. *International Journal of Social Economics* **48** (4), 543–556. doi:10.1108/IJSE-08-2020-0582.
- Andeobu, L., Wibowo, S. & Grandhi, S. 2022 *Medical waste from COVID-19 pandemic – a systematic review of management and environmental impacts in Australia*. *International Journal of Environmental Research and Public Health* **19** (3), 1381. doi:10.3390/ijerph19031381.
- Badri, B. 2020 *The Impact of COVID-19 on Women*. United Nations Chronicle, New York, USA.
- Bukari, C., Essilfie, G., Aning-Agyei, M. A., Otoo, I. C., Kyeremeh, C., Owusu, A. A., Amuquandoh, K. F. & Bukari, K. I. 2021 *Impact of COVID-19 on poverty and living standards in Ghana: a micro-perspective*. *Cogent Economics & Finance* **9** (1). doi:10.1080/23322039.2021.1879716.
- Bukari, C., Aning-Agyei, M. A., Kyeremeh, C., Essilfie, G., Amuquandoh, K. F., Owusu, A. A., Otoo, I. C. & Bukari, K. I. 2022 *Effect of COVID-19 on household food insecurity and poverty: evidence from Ghana*. *Social Indicators Research* **159** (3), 991–1015. doi:10.1007/s11205-021-02766-9.
- Caruso, B. A. & Freeman, M. C. 2020 *Shared sanitation and the spread of COVID-19: risks and next steps*. *The Lancet. Planetary Health* **4** (5), e173. doi:10.1016/S2542-5196(20)30086-3.
- Cerrada-Romero, C., Berastegui-Cabrera, J., Camacho-Martínez, P., Goikoetxea-Aguirre, J., Pérez-Palacios, P., Santibáñez, S., Blanco-Vidal, M. J., Valiente, A., Alba, J., Rodríguez-Álvarez, R., Pascual, A., Oteo, J. A., Cisneros, J. M., Pachón, J., Casas-Flecha, I., Cordero, E., Pozo, F. & Sánchez-Céspedes, J. 2022 *Excretion and viability of SARS-CoV-2 in feces and its association with the clinical outcome of COVID-19*. *Scientific Reports* **12** (1), 7397. doi:10.1038/s41598-022-11439-7.
- El-Baz, L. M. F., Khalid, Z. E. & Elgarahy, A. M. 2020 *COVID-19 from mysterious enemy to an environmental detection process: a critical review*. *Innovative Infrastructure Solutions* **5** (3), 1–13. doi:10.1007/s41062-020-00334-7.
- Ghana Center for Democratic Development 2021 *Impact of COVID-19 on Government's Reform Programmes in Ghana: Final Research Report*. Ghana Center for Democratic Development, Accra, Ghana. Available from: https://cddgh.org/wp-content/uploads/2021/12/CDD-GIZ_COVID-19-Studies-Ghana.pdf (accessed 16 January 2023).
- Giné-Garriga, R., Delepiere, A., Ward, R., Alvarez-Sala, J., Alvarez-Murillo, I., Mariezcurrena, V., Sandberg, H. G., Saikia, P., Avello, P., Thakar, K., Ibrahim, E., Nouvellon, A., El Hattab, O., Hutton, G. & Jiménez, A. 2021 *COVID-19 water, sanitation, and hygiene response: review of measures and initiatives adopted by governments, regulators, utilities, and other stakeholders in 84 countries*. *Science of The Total Environment* **795**, 148789. doi:10.1016/j.scitotenv.2021.148789.
- Haji, B. A., Shahin, M. S., Sangani, M. M. M., Faghihinezhad, M. & Baghdadi, M. 2021 *Wastewater aerosols produced during flushing toilets, WWTPS, and irrigation with reclaimed municipal wastewater as indirect exposure to SARS-CoV-2*. *Journal of Environmental Chemical Engineering* **9** (5), 106201. doi:10.1016/J.JECE.2021.106201.
- Huston, A. & Moriarty, P. 2018 *Building Strong WASH Systems for the SDGs: Understanding the WASH System and Its Building Blocks*. IRC International Water and Sanitation Centre Working Paper IRC-WSS-WP-2018-01, The Hague, Switzerland.
- IRC International Water and Sanitation Centre 2020 *Silver Linings of the COVID-19 Crisis in Ghana*. Available from: <https://www.ircwash.org/blog/silver-linings-covid-19-crisis-ghana> (accessed 16 January 2023).

- Kotwa, N., Gilsdorf, R. J., Mehta, N. & Gambrell, M. 2020 *To Share or Not to Share Sanitation Facilities: A Coronavirus Conundrum*. Available from: <https://blogs.worldbank.org/water/share-or-not-share-sanitation-facilities-coronavirus-conundrum> (accessed 16 January 2023).
- Lewis, D. 2021 COVID-19 rarely spreads through surfaces. So why are we still deep cleaning? *Nature* **590** (7844), 26–28. doi:10.1038/D41586-021-00251-4.
- Ministry of Finance 2019 *Composite Budget for 2019–2022: Programme Based Budget Estimates for 2019 Ayawaso East Municipal Assembly*. Available from: <https://mofep.gov.gh/sites/default/files/composite-budget/2019/GR/Ayawaso-East.pdf>.
- Ministry of Health 2020 *Ghana COVID-19 Emergency Preparedness and Response Project & Additional Financing*. Available from: <https://www.moh.gov.gh/wp-content/uploads/2016/02/FINAL-COVID-19-ESMF.pdf> (accessed 16 January 2023).
- Ministry of Sanitation and Water Resources n.d. *Donation of Veronica Buckets to the Ministry of Sanitation and Water Resources*. Ministry of Sanitation and Water Resources. Available from: <http://mswr.gov.gh/donation-of-veronica-buckets-to-the-ministry-of-sanitation-and-water-resources/?print=print> (accessed 16 January 2023).
- Morgan, A. K. 2020 Making COVID-19 prevention etiquette of social distancing a reality for the homeless and slum dwellers in Ghana: lessons for consideration. *Local Environment* **25** (7), 536–539. doi:10.1080/13549839.2020.1789854.
- Paramita, W., Rostiani, R., Winahjoe, S., Wibowo, A., Virgosita, R. & Audita, H. 2021 Explaining the voluntary compliance to COVID-19 measures: an extrapolation on the gender perspective. *Global Journal of Flexible Systems Management* **22** (1), 1–18. doi:10.1007/S40171-021-00261-1/TABLES/6.
- Schotte, S., Danquah, M., Osei, R. D. & Sen, K. 2021 *The Labour Market Impact of Covid-19 Lockdowns: Evidence From Ghana*, Vol. 2021. The United Nations University World Institute for Development Economics Research is part of the United Nations University, Helsinki. doi:10.35188/UNU-WIDER/2021/965-5.
- Statistical Service Ghana 2020 *How COVID-19 Is Affecting Firms in Ghana: Results From the Business Tracker Survey*. Statistical Service Ghana, Accra, Ghana. Available from: https://statsghana.gov.gh/covidtracker/Business%20Tracker%20Brief%20Report_GSS_web.pdf (accessed 16 January 2023).
- Stockholm International Water Institute 2020 *Overview of Water, Sanitation, and Hygiene (WASH) COVID-19 Responses from Governments, Regulators, Utilities and other Stakeholders in 84 Countries*. SIWI, Stockholm. https://siwi.org/wp-content/uploads/2020/08/20200701_Mapping-WASH-COVID-19_Key-remarks_v6_clean-Aug-10-.pdf. (accessed 16 January 2023).
- Sugihara, R. 2020 Reuse of human excreta in developing countries: agricultural fertilization optimization. *Consilience* **22**, 58–64.
- Tagoe, E. T., Nonvignon, J., van der Meer, R., Megidido, I. & Godman, B. 2022 Challenges to the delivery of clinical diabetes services in Ghana created by the COVID-19 pandemic. *Journal of Health Services Research & Policy* **28** (1), 58–65. doi:10.1177/13558196221111708.
- Tetra Tec 2021 *Assessing the Effects of COVID-19 on Access to Water, Sanitation, and Hygiene in Usaid High Priority and Strategy-Aligned Countries Country Deep Dive Report – Ghana*. Available from: https://pdf.usaid.gov/pdf_docs/PA00XDMX.pdf (accessed 16 January 2023).
- Tsukiji, M., Gamaralalage, P. J. D., Pratomo, S. Y., Onogawa, K., Alverson, K. K., Honda, S., Ternald, D., Dilley, M., Fujioka, J. & Condorrini, D. 2020 *Waste Management During the COVID-19 Pandemic: From Response to Recovery*. UN Environment Programme, New York, USA. Available from: <https://www.unep.org/resources/report/waste-management-during-covid-19-pandemic-response-recovery> (accessed 16 January 2023).
- WHO/UNICEF/JMP 2019 WHO/UNICEF Joint Monitoring Programme. <https://washdata.org/> (accessed 10 October 2023).
- World Health Organization 2020 *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - March 11, 2020*. Available from: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020> (accessed 16 January 2023).
- World Health Organization 2022 *Tonnes of COVID-19 Health Care Waste Expose Urgent Need to Improve Waste Management System*. Available from: <https://www.who.int/news/item/01-02-2022-tonnes-of-covid-19-health-care-waste-expose-urgent-need-to-improve-waste-management-systems> (accessed 16 January 2023).

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