

Integrating Geo-Information Science and Strategic Communication to Strengthen Community Participation in Environmental Sanitation: A Mixed-Methods Participatory Research Protocol for Adukrom, Ghana

Beverla Edna
Information Services Department, University of Ghana, 751 Obuasi, Ghana

* Corresponding Author: **Beverla Edna**

Article Info

E-ISSN: 3107-7129
Volume: 02
Issue: 06
Received: 08-09-2026
Accepted: 06-10-2026
Published: 04-11-2026
Page No: 31-44

Abstract
Environmental sanitation in Adukrom, the capital of the Okere District in Ghana's Eastern Region, remains a pressing local governance issue. However, institutional records alone cannot determine household-level participation, communication effectiveness, or spatial differences in service provision. The population's reported health priorities can help local authorities identify spatial gaps in sanitation provision, and household perceptions of participation and communication practices will reveal whether there are barriers to the sanitary improvement of the area. This study will test hypotheses concerning the accessibility of sanitation services and the level of participation and effectiveness of communication on sanitation services. To investigate the perceptions of households in Adukrom and the surrounding Okere District regarding sanitation communication, participation, accessibility, and service delivery, we will employ a convergent mixed-methods participatory design. Data will come from household surveys, key-informant interviews, focus group discussions, service mapping using GPS (global positioning system) and participatory GIS (geographic information system). Adukrom will be divided into analytically meaningful zones, and households will be selected using Cochran's formula and a finite-population correction approach. Participatory methods will be used to map sanitation facilities and hygiene hotspots, while buffers and distance measures will assess access to illustrate priority areas for intervention and gaps in service. A composite communication-quality index will be developed based on participatory communication theory, the theory of planned behavior, and Arnstein's ladder of participation. Data analysis will include descriptive statistics, reliability analysis, chi-square tests, correlation analysis, and regression analysis, while qualitative data will be analyzed thematically. An assessment of spatial-data readiness indicates that, although the Ghana Open Data Initiative provides layers for regional and district boundaries, as well as road networks, locality-level census extracts and data on existing sanitation facilities remain unavailable. Additional field data collection and verification will therefore be required before the final sampling frame can be prepared and spatial analyses undertaken. The final protocol will guide local authorities in integrating spatial evidence with local knowledge of sanitation conditions, service-delivery patterns, community participation, and communication.

DOI: https://doi.org/10.54660/.IJHSI.2026.2.6.31-44

Keywords: Geo-Information Science, Strategic Communication, Community Participation, Environmental Sanitation, Participatory Mapping, Adukrom-Ghana, Public Health

Introduction

The issue of environmental sanitation is multifaceted because it deals with public health, environmental quality, local governance concerns, and community agency. Hence, sector-specific solutions cannot sustainably improve outcomes. Ghana's sanitation and waste management systems are a truly "wicked" policy domain. The dynamics of this sector are influenced by the relationships among MMDAs (metropolitan, municipal, and district assemblies) and a wide range of interactions between

various institutions within this field (Adorsu-Djentuh, 2018) [2]. These interactions between the primary actors, their roles, and their treatment as chains are inherently complicated. The involvement of multiple ministries in providing responsibility for sanitation can mean conflicting priorities, regulations, and standards (Asokwah *et al*., 2026) [7]. Government accountability may not extend to civil society, while the quality of services can vary dramatically depending on the institutional ability to coordinate the actions and account for the results of private providers and consumers. It may sound paradoxical in this day and age, but local government incapacity driven by the poor coordination and accountability required of such a tricky policy field as sanitation may constitute a greater obstacle to improved performance than technical or financial shortfalls. Therefore, the midterm challenge confronting Ghana in achieving health-related Sustainable Development Goals is not so much the lack of funding as the ability to improve the coordination of health priorities entailed in the budgets (Doku *et al*., 2026) [11]. The extent to which Ghana's assemblies have budgetary incredibility, a specter that swathes itself around all good intentions, determines ultimately whether the budgets that are passed are credible and enacted.

Moreover, the mere availability of toilets, waste containers, and drains is an inadequate measure of the success or otherwise of sanitation. Sustainable outcomes depend on the availability of relevant information, the existence of a trusting relationship with the institutions involved, and the participation of the communities in addressing what they see as the problems and in their resolution. Called the District Assemblies in Ghana, local government gave access to sanitation services a high priority in Adukrom-Akuapem, as recorded in District Assembly minutes. Presumably, records contain no information about household participation in sanitation nor about the effectiveness of sanitation service communication. They are unable to indicate or illustrate spatial disparities in the sanitation services offered or how these disparities influenced specific behaviors. However, it is possible that local priority placed on sanitation services by the District Assembly was determined by public-health concerns, particularly as they relate to the environment. Environmentally related disease is a documented public-health concern in the wider district; for example, a matched case-control study of Buruli ulcer that included Akwapim South and Akwapim North-Okere identified farming without adequate protective clothing and proximity to waterbodies as the main risk factors (Gohoho *et al*., 2025) [19], although that study did not examine sanitation provision directly. Domestic wastewater has thus been a concern of Akwapim's local government. Additionally, in our analysis of sanitation communication, it is particularly important to understand how tradition influenced sanitation communication production, as well as to the extent that service delivery occurred, among other aspects. Chieftaincy institutions operate as neotraditional development brokers within the District Assembly framework. Knierzinger (2011) [20] elaborates on how such traditional institutions mediate participation of chiefs in the District Water and Sanitation Team.

Sanitation, as we shall see, is a gender- and care-work-differentiated service that requires coordination of urban plans and investments by local government bodies. Individual behavior cannot explain unequal sanitary conditions (Brewer, 2022) [9]. This asks for an integrated approach to spatial evidence and strategic communication, treating them as dynamically interrelated and influencing each other rather than as applied separately. Geographic Information Systems (GIS) can pinpoint the site of sanitation problems and the location of services that should be delivered. Participatory mapping can explain local conditions and causes of these patterns and present the justification for interventions to constituencies concerned. The results of dialogue, information, and collectivity are then pulled together and made effective by strategic communication. The first paradigm behind the protocol is Participatory Communication Theory. In particular, this emphasizes dialogue as a means of drawing on local knowledge, inclusion of everyone affected, and empowering communities to shape their own solutions (Tufte & Mefalopulos, 2009) [31]. The Theory of Planned Behavior, which analyzes attitude and subjective norms, perceived behavioral control, intentions, and behavior (Ajzen, 1991) [3], helps address the attitude-related issues shaping whether or not people adopt 3S sanitation behaviors. Extending the analysis further, Arnstein's (1969) [6] Ladder of Citizen Participation helps us also distinguish between those actions that involve informing and consulting (as opposed to partnership and sharing in decision-making). The two paradigms help connect the structural sanitation conditions and the individual and social dynamics shaping local people's actions. In this study, participatory GIS intersect with household surveys and qualitative evidence in a convergent mixed-methods framework.

The WIAFE project thus bridges local community knowledge about geospatial information with formal spatial analytical methods, contributing to academic discussions on human settlements and service accessibility. Within the scholarship on development communication, the project situates its findings within the literature on practice and real-world applications. It explicitly foregrounds the global South perspectives on community participation, development communication, and waste management infrastructures. In addition, it addresses complex multidisciplinary environmental-development challenges in which governance, human behavior, and spatial configurations cannot be disentangled analytically. The goal of the study is to develop and test the efficacy of an integrated framework for promoting community participation in environmental sanitation. It is hypothesized that using spatial evidence coupled with effective communication will yield higher levels of community environmental sanitation participation than interventions based on either evidence or communication alone, in which the quality of the communication intervention may act as a moderator of response to spatial information as expressed via participation. The authors make no causative claims regarding the nature of the findings from this study; instead, it is intended to be considered in conjunction with all the other findings as triangulation evidence that informs support for, or refutation of, the hypotheses proposed.

Literature Review

In reviewing the broad research on community participation in sanitation, one increasingly notes the fragmentation of knowledge by the disciplinary traditions from which it emerged. The more recent literatures (Abalo *et al*., 2017; Asokwah *et al*., 2026) [1, 7] addresses the fact that community participation in sanitation (i.e., sanitation programs) may also

function as a tool of governance. The authors of the National Sanitation Day program in Aboabo, Ghana, noted that it required a high degree of community mobilization and local leadership beyond its activities outlined on a calendar (Abalo *et al*., 2017) [1] and explained that failures in sanitation were not just a matter of lack of technical provision but rather one that revolved around poor accountability and coordination (Asokwah *et al*., 2026) [7]. Many of these studies evaluate participation by the number of attendees or those who self-identify their involvement. Rarely do studies situate participation within the geographic context of how sanitation services are distributed. Understanding sanitation behavior can be informed by two theories that produce behavioral predictions: the Theory of Planned Behavior (TPB) and Community-Based Social Marketing (CBSM). The TPB includes constructs for identifying antecedents of behavior, such as attitudes toward the behavior and subjective norms. TPB specifically includes perceived behavioral control, which makes it a good fit for sanitation contexts in which households face obstacles to adoption and implementation of desired sanitation behaviors beyond the locus of personal agency (Ajzen, 1991) [3]. CBSM emphasizes the role of barriers to behavior change, arguing that simply transmitting information to residents is inadequate unless the unique barriers to behavioral uptake are also addressed (McKenzie-Mohr, 2000) [25]. Subsequent work on promoting sustainable behaviors also follows. It is important to note, however, that models such as TPB and CBSM, including their emphasis on barriers, are largely spatially blind (Dreibelbis *et al*., 2013) [12]. They explain individual behavior but not the distribution of sanitation facilities across settlements.

Participation should never be construed primarily as a way to transmit information. It should be rather as Otto and Fourie (2016) [29] say: “An interactive process that promotes mutually beneficial communication between the parties involved." Arnstein (1969) [6] points out that citizen control and partnership are qualitatively different from manipulation and consultation, and these differences are important to note here. The contributions of participatory GIS are socially constructed, ranging from grassroots advocacy through public participation in policymaking to participatory planning (Sieber, 2006) [30]. There is a danger that we assume participatory GIS will have positive contributions to natural resources governance rather than evaluating what “positive” might mean (McCall & Minang, 2005) [24]. “Different sets of participatory spatial-planning processes must be designed to ensure that the geo-information tools will assist in meetings of accountability and legitimacy” (McCall, 2003) [23]. Recent reviews (Marondedze *et al*., 2024) [22] have shown that participatory GIS, while promoting equity and inclusion in broader stakeholder engagement in urban land-use planning, nevertheless challenges related to power dynamics remain, often necessitating ongoing facilitation to level the playing field. Participatory GIS helps bring communities along to visualize data, while citizen science expands the variety of people engaged, but this does not guarantee communities any greater degree of decision-making authority (Ntassiou, 2025) [26].

While these reviews highlight the potential of participatory mapping, little attention is given to how theories of behavior and communication can be integrated, not simply for knowledge production but to enhance the process of spatial analysis. The connections between other service deficits, information sharing, and participation are often neglected. In Ghana, research on sanitation has been less concerned with understanding the spatial inequalities inherent in access and instead focused on high-level governance and behavioral issues. Places like Adukrom have received limited attention as a space where spatial and interpretative inequalities may be examined. Thus, an integrated study centered on participatory sanitation research design was proposed in which all three of the theories would be synthesized into an appropriate convergent mixed methods approach, deploying both household surveys and qualitative interviews (for communication quality) and GPS-mapped participatory GIS (for service pattern) as integrated components of a single research design rather than treating them as two separate interventions. The analysis would be focused on the ways in which these various components interrelate with one another in a small town, assessing the quality of sanitation conditions and services, while also triangulating evidence about the quality of communication and participation.

Study Setting and the Sanitation Challenge in Adukrom, Okere District

Adukrom-Akuapem is the capital town of Okere District, situated in the Eastern Region of Ghana (Okere District Assembly [OkDA], 2024) [28]. It is very close to the corridor that runs between Accra, Koforidua, and Hohoe in the northeastern part of the country, with approximate geographical coordinates of 6.02° N and 0.08° W for the district (OkDA, 2024). The location and physical characteristics of the hilly and undulating Akuapem Ridge pose challenges in selecting suitable sites for some sanitation facilities, as well as achieving gravity-fed discharge of stormwater. According to the 2021 Population and Housing Census, the population of Okere District in 2021 was 51,675 people (Ghana Statistical Service [GSS], 2021) [17]. Adukrom is the major urban settlement of the district and constitutes a large part of the population of the district. Note also that data at the district level do not provide a valid basis for estimating the population of Adukrom unless local-level data on settlements are made available. In the Okere District's Medium-Term Development Plan, we discovered that the responsibility for adequate sanitation has been given to the district assembly, the private sector operator, and traditional authorities by the National Environmental Sanitation Policy and other strategies (Kosoe & Ahmed, 2024) [21]. District responsibilities include providing an acceptable type of toilets in households; private ownership and operation of public latrines; collection of solid waste; and maintenance of drainage systems. However, the Assembly’s district profile reports that not all household waste generated is collected and transported to final disposal sites, that only one waste management company operates in the district, and that the Assembly is working toward making all communities open-defecation free (OkDA, 2024). The information gleaned from the Okere District's Medium-Term Development Plan, while likely not specific to Adukrom, suggests that waste management and sanitation remain a challenge for local government in the Okere District.

For this research, the district boundary and the road network were both based on administrative information sourced from the Ghana Open Data Initiative (Ghana Open Data Initiative, n.d.). Both layers contained Open Data provenance, providing the source of the data, the date-of-source, and the coordinates reference system (in this case geographic coordinates in WGS 84, EPSG:4326). The drainage

alignments were digitized on the ground from Google Earth's recent satellite imagery (2023) at a very high resolution, meaning that they are likely to be sufficiently accurate for analysis and integration with the other layers. However, the sanitation data layer (ditches, public latrines, waste collection routes) is still being compiled for the Okere District Assembly, and the main distance analysis of accessibility with its buffers will not take place until accuracy can be verified with ground-truthing in the field. It is crucial to maintain the provenance of each layer throughout the flowchart of subsequent layers, and layers with dubious provenance must not be used as a basis for a final analysis. Properly defining the sanitation habits and sanitary condition of the village of Adukrom, as gathered from secondary data, is impossible for one who has not had an opportunity to visit it. The problem presented is one of conditions and locations as well as of communication, and the true evidence of relative weight can only be determined by a personal visit to the place, which involves the securing of primary data from each household, the inspection of its location with reference to available sanitary service and drainage, and the study of the influence of sanitary education.

A Convergent Mixed-Methods and Participatory GIS Protocol

A convergent design represents an alternative to the explanatory sequential design. In that design, quantitative data precede qualitative data collection. In contrast, the convergent design collects and analyzes quantitative, qualitative, and geospatial data concurrently, integrating results to interpret a common outcome. (Fetters *et al*., 2013) [14]. In the case at hand, the quantitative data from the household survey provided descriptive evidence of the patterns of participation, levels of knowledge, and amounts of exposure to service advertising among members of the settlement, while the qualitative evidence provided explanatory detail regarding the reasons for those patterns and the related dynamics within the institutions. The geospatial evidence established the locations of the service conditions to which the survey and qualitative results referred. Just as triangulation linked the multiple data sources and perspectives in explanatory design, triangulation prompted the integration of quantitative and qualitative results in the convergent design, allowing for the identification of both similarities and discrepancies across results regarding what people involved in the relevant institutions said, how people living within the community understood and talked about the services, what appeared to be happening in the field in terms of conditions of service to households, and where those conditions resided spatially. To establish a framework for the final analysis, the results of the quantitative, qualitative, and spatial analyses were brought through a common literal interpretation into a joint interpretive matrix.

Data Collection and Evidence Streams

These quantitative and qualitative data are gathered primarily through two instruments: a structured questionnaire administered within households and key informant interviews. The questionnaire gathers data on respondents, including their age, gender, and education; knowledge levels, attitudes, and perceived ability to participate in sanitation provision; level of trust in formal sanitation institutions; and patterns of exposure to sanitation information together with information about household sanitation practices and participation in programs or services. The key informant interviews are semi-structured to accommodate new lines of questioning and to elicit new insights that are not likely to arise from standardized questions. Key informants include environmental health and district sanitation officials, waste management officials, leaders of traditional councils and assemblies, community health workers, religious leaders, teachers, representatives of youth and women's groups, and leaders of civil society. Interviews with these informants will elicit perceptions about institutional approaches to sanitation problems, constraints to action, information systems in place, and community responsiveness to sanitation problems. In addition, men's and women's groups provide didactic lessons on gendered and generational differences in sanitation experience. Gender archetypes tend to silence other voices, so we obtain better information through gendered and generational group separation, creating the space for authenticity.

Direct observation is recorded on a standardized checklist covering visible waste accumulation, drain condition, latrine cleanliness and functionality, and the presence or absence of collection containers at designated points. Finally, a communication-material inventory documents the posters, notices, radio segments, and digital messages that are actually in circulation, together with their language, source, and stated behavioral instruction. Secondary data are assembled in parallel and used to contextualize rather than to substitute for primary evidence. These comprise district sanitation records, the Okere District Medium-Term Development Plan, census information, sanitation-service records, road and drainage layers, satellite imagery, and relevant national sanitation documents. The secondary sources serve three functions: they define the institutional and policy environment within which local sanitation is administered, they supply the administrative and network layers on which spatial analysis depends, and they provide the baseline against which field-verified conditions can be compared. Where a secondary record conflicts with field observation, the conflict is retained as an analytic finding rather than resolved by default in favor of the official source.

We then go on to collect secondary data, each in the following steps:

1. Site mapping. Using the current year's satellite imagery, road and drainage network datasets, and census and sanitation service datasets gives an understandable overview of the layout of the district and especially allows the research team to check for the resemblance in the field data with the institutional context and basic sanitation data.
2. District-wide assessment of sanitation-related data. A review of existing official report publications from the district, the Okere District Medium Term Development Plan, and national sanitation reports supply contextual material for the primary data and offer a comparison basis for the actual investigation.
3. The communication materials assessment identifies how messages about sanitation are being delivered to the population. It surveys the physical presence of posters, notices, and/or sheets of audio-visual communication materials, with an inventory checklist for determining the language, delivery source, and proposed behavior change each contains.

4. Data collection using a checklist contains how much rubbish is around and the state of drains, latrines, and collection containers at specified locations.

Sampling Strategy

First, spatial stratification. In order to analyze the data sensibly, it is necessary to take account of the physical and/or social situation in which the households of Adukrom find themselves. The appropriate dimensions of spatial stratification will vary depending upon the different types of data but generally will be determined by a combination of concerns such as the geographical boundaries of neighborhoods; the knowledge of the local spatial distribution of population; road configuration; the local government 'zones of service'; the land use in the area; and the government-recognized wards corresponding to the special neighborhoods or settlements in Adukrom. The goal is to treat the entire range of service conditions in Adukrom to avoid clustering responses in the middle of the town where accessibility is greatest. The neighborhoods, once clearly identified, must then be digitized as polygons again within the geodatabase. Each neighborhood should be assigned a unique identifier linking the households, the observational data, and the respective georeferenced data in such a way that the precise geolocations as such cannot be recovered to protect the privacy of respondents. The selection of the households can be accomplished in three ways. If there is a complete list of households found available, the best method is random selection. If not, the preferable method is systematic selection, that is, arranging the units in the cluster to be sampled in a definite order along a line traversing the territory as the housing lay-out.

The households are organized sequentially, starting from this line, and every kth unit is selected until the desired sample size is achieved, where k is calculated as the total number of households divided by the quota of households (Cochran, 1977) [10]. This approach is applicable only when a complete enumeration is not available. With the sampling frame established in the second stage of the survey, it is crucial to ascertain the necessary amount of sampling. It is important to recognize that there are several similarities to Stage I in this process. Cochran's (1977) [10] formula (1) now gives (4) the measure of sample units, and applying (5) the finite population correction, we have the desired figure and must be multiplied by the anticipated rate of non-response. The Adukrom correction cannot yet be applied to the current situation because we do not know the approximate number of households in this locality. Therefore, the exploratory enumeration must be relied upon for constructing the appropriate frame, and the number of households must be multiplied by the anticipated rate of non-response. The sampling of the stakeholders is purposive, and the manner in which the frame is to be constructed will involve discussion with the appropriate parties.

Geospatial Methods

Other essential information to record includes GPS locations of public sanitation facilities, household-based sanitation facilities (individual toilets, pour-flush latrines, etc.), community sanitation facilities, waste containers, waste collection points, waste-receiving sites, drainage sites, and all forms of stagnant water (e.g., lakes, ponds, swamps, paddy fields). All data should also include a date/time stamp, accuracy of the position at the observed location, and the identifier of the field observer. Further, any positions of latrine, etc., should involve an accuracy check and should only be recorded after a fix is obtained that meets the recorded accuracy tolerance for the position. For analytical use, particularly in household surveys, it may be useful to obtain coordinates on individual houses. However, it is usually wise to ensure that the position of these houses cannot be identified at anything more than a highly aggregated level on any other layer of the mapping operation. It may be best to structure the database into thematic layers, i.e., with each layer representing a defined theme. As a guide, the following seven thematic layers could be used: administrative, population, infrastructure, sanitation, environment, services, and community layers, as shown in Table 1. Each layer should contain a set of data based on common infrastructure, e.g., boundaries and sampling zones; census and sampling areas; roads, schools, and health facilities; toilets and waste points; drains and water bodies; waste collection routes and service areas; and features and participatory mapping processes. All layers should be referenced in a standard manner in one single geographic coordinate system. All features in the database should also be accompanied by metadata files that provide information on the source of the data, the dates of acquisition, and the processing history for the data.

Table 1: Thematic layers of the proposed spatial database

Layer	Example contents
Administrative	Study boundary, sampling zones
Population	Census areas, sampling areas
Infrastructure	Roads, schools, health facilities
Sanitation	Public toilets, waste containers, collection points
Environment	Drains, water bodies, stagnant-water sites
Services	Collection routes, service areas
Community	Participatory mapping features

For each household or any other unit of spatial analysis i, calculate the distance to the nearest appropriate sanitation service point j. If network distance data are available, calculate distance along the road network; otherwise, use Euclidean distance as a first step. Deviate from Euclidean distance (for example, road network-based distances) when planning to incorporate other variables into the gravity model, for the reasons explained earlier. Euclidean distance underestimates the burden where topography is hillier or roads do not provide a direct route, but it is often preferable when the purpose of the analysis is simply to flag proximity (Apparicio *et al*., 2008) [5]. Great care is needed, however, not to equate physical proximity for which distance data are available with functional proximity (accessibility, affordability, or reliability) for which additional data are needed. No matter how distances are calculated, planning requires circumspection in establishing the radius for which to analyze the data. For some analyses, the boundary may best be defined in terms of the research question rather than by an arbitrary distance. The same caution holds for analysis of buffer zones based on public toilets, waste containers, collection points, or drains. The Kernel Density Estimation (KDE) approach, or Getis–Ord Gi* hotspot analysis (Getis & Ord, 1992) [15], should only be included in the research plan if the evaluation of the density or clustering of sanitation service points (or any other point pattern) is intended.

Evaluation of point patterns requires that adequate observations be collected and, in order for hotspot analysis to

be meaningful, that those observations demonstrate a complete, representative spatial sample. Only in rare instances will hotspot results serve as final findings; most often they are considered provisional, conditional upon the quality of the point pattern evaluated. Participants can then self-report other features relevant to sanitation issues such as service gaps, blocked drains, areas where waste accumulates, collections points, resources, etc. Participants can also report specific problem locations and designate priorities for remediation. The features reported by the community can be digitized into a "community" layer. This layer can then be contrasted with the observed data recorded using GPS as well as institutional records. Disparities between official maps and community maps are retained as part of the evidence. Maps of discrepancies reveal that understandings of sanitation are different from what institutions are able to map. Errors are not being corrected here; rather, differences are acknowledged.

Communication Assessment

The next step is to assess all of the various communication channels, the sources of messages, and the quality of incoming communication. You might want to consider people-to-people communication, public meetings, the role of local/traditional/religious authorities, the role of mass media such as radio, posters, and the internet, including mobile phones and social media, and the role of public announcements. Such channels may emanate from various sources such as the district authorities, health officers, traditional/religious leaders, health workers, schools, community organizations, and waste service providers. Consider also the quality of communication, getting respondents to rate its credibility, clarity, relevance, frequency, language, accessibility, responsiveness, and opportunity for feedback using Likert-type items. Once the quality of various channels has been assessed and found to be internally consistent (using Cronbach's alpha), consider performing an exploratory factor analysis. If all the items load on the intended dimension or construct, create a composite index of the communication quality variable. However, if there are items that load on more than one factor, report the results as distinct subscale scores.

Data Analysis

Once the participation measures are created, the analyst starts over, exploring the data to understand the distributions and correlations of the various measures. This means looking at descriptive statistics (frequencies, percentages, means, medians, standard deviations, and cross-tabulations), assessing scale reliability, frequently by means of Cronbach's alpha (or another appropriate measure, depending on the nature of the scales), and performing tests of association (typically chi-square tests for categorical measures and correlation tests for continuous/ordinal indices). Regression models can also be created for each unit to identify the predictors of participation, that is, to answer the question, "What is it about each unit that predicts how much participation they achieve?" Which sort of regression analysis should be performed depends, of course, on the units of analysis and how participation is operationalized, with logistic regression being used for binary-dependent variable participation, Poisson regression or negative binomial regression being used for count-based dependent variables, and linear regression being used for validated continuous indices of participation. As earlier mentioned, it is important to check assumptions when interpreting regression models, and overdispersion needs to be checked explicitly in count models.

Qualitative data (interviews and focus groups) were transcribed verbatim, open coded, consolidated into candidate themes, and then reviewed against the entire data set to check each theme's relevance (Braun & Clarke, 2006) [8]. Terms like trust, exclusion, psychosocial barriers to access, institutional responsiveness, leadership, perception of waste service availability, and community ownership were distinguished under the theme. The demographic variables examined included people's gender, their age (e.g., youth), their perception of health risks related to poor sanitation, and the perceived push and pull factors associated with increased participation. GIS methods produced a variety of results analyses, including the location of facilities, areas of waste accumulation, access to services, access to different groups, service coverage rates, spatial inequality, maps created by participatory mapping, and identifying areas of prioritized intervention. Each map included a north arrow, scale bar, legend, and source of information. The qualitative findings were triangulated with the institutional reports, the residents' accounts, and the quantitative spatial analyses. Reports were reproduced to juxtapose areas of agreement (triangulation) and disagreement (source-triangulation).

Validity, Reliability, and Trustworthiness

Validation of questionnaires is strengthened through expert reviews, pilot testing, and translation/back-translation procedures, as well as checks for internal consistency of responses to multi-item scales. Training of field teams is standardized, and procedures for spot-checking interviews are used to assess enumerator reliability. Similarly, standardization in use of GPS equipment and procedures supports comparability among all observers. Validity and reliability of observational coding work are strengthened by determining inter-rater reliability. Qualitative data are subjected to member checking, and raw data (e.g., transcripts) are accompanied by reflexive statements by researchers. Although not always possible owing to the realities of time and resources, GIS products will have clearly defined metadata and a solid record of how spatial information generated by communities was interpreted. Mapping reports will also attempt to be transparent about other voices and perspectives that were not included in the community mapping meetings.

Ethical Considerations

Ethical approval is obtained before conducting any fieldwork. Provide participants with information (in plain language) regarding the study, including that their participation is voluntary, that benefits and risks for their involvement may exist, that their responses will remain confidential, that they can withdraw from the study at any time without penalties, and that their consent is required in order for research to proceed. Be careful about releasing precise coordinates of participating households to protect participants' privacy; aggregate spatial results to the level of zones or otherwise generalize spatial results to prevent reidentifying individuals. Do not, for instance, label neighborhoods as "dirty" or "problematic," or refer to residents as "lacking sanitary practices" when services are inadequate or institutions are failing.

Proposed Strategic Communication Intervention

Before designing the commitment and communication interventions, the baseline survey results for GIS data and communication should be available. By not jumping to conclusions, decisions can be based on what the survey results show rather than assumptions. In other words, audiences should be segmented accordingly based on survey and qualitative results and not preconceived notions about demographics. Final messages should be tailored to the behavioral barriers revealed by research. To ensure cultural meaning is used, rather than simply translation, materials need to be developed in the actual language of the audience. Messengers should be selected based on the research on credibility and the engagement of appropriate community members. This would generally include consultation with traditional/modal leaders, as well as health workers, teachers, sanitation officers, community representatives, and leaders of youth and women's groups. Link different communication channels, such as durbars, forums, radio, schools, places of worship, peer-to-peer, notices, WhatsApp groups, online platforms, participatory maps, and community scorecards to create an integrated system for sharing information with residents about services on offer and encouraging feedback from residents to inform service providers on sanitation issues of concern.

The system must facilitate two-way communication, allowing residents to notify service providers of sanitation issues, their specific locations, and, if feasible, any evidence related to these problems. Residents must get feedback on the receipt and progress of issues raised and be asked for further feedback regarding whether problems have been fixed. The community sanitation dashboard must provide evidence of sanitation service coverage, accessible locations, complaints received, resolved issues, priority areas of concern ('hot spots'), and the status of responses from service providers, but it must never compromise the confidentiality of household-level issues by exposing sensitive information.

Monitoring and Evaluation

At the end of the intervention, the following indicators should be reported: the number and percentage of residents receiving sanitation information; the number and percentage of residents able to identify a source of information considered credible; the community participation index and the number of participatory mapping sessions conducted; the number of sanitation problems reported and percentage addressed; the number of hotspots identified and percentage of priority hotspots addressed; the institutional trust index and sanitation behaviors index; and the baseline values for these indicators, disaggregated for each region and for both genders, should once again be reported for comparison.

Results Presentation

The results of this study on sanitation are disclosed in tables providing socio-demographic characteristics, household sanitation facilities and associated practices, communication channels, perceived credibility, and statistics relating to scale reliability and validity. Another table describes the predictors of community participation, while the Adukrom study boundary, sampling locations, the distribution of sanitation facilities, waste accumulation, and service access are illustrated in figures. Additional figures are employed to present the participatory community sanitation map, the GIS-actionability-communication intervention framework, and the delineation of sanitation-priority areas. Qualitative findings are reported with matrix displays of thematic-analysis text and illustrative quotes from participants following the removal of any identifying information.

Limitations

Using the household surveys, we established correlations but not temporal causation, and we recognized that self-reported sanitation behavior could suffer from recall bias and social desirability bias (Althubaiti, 2016) [4]. While our observational and GIS data provided some mitigation of these concerns, reliance on subjective measures and data that depended on households to be complete and geolocated meant that results could not be entirely definitive. Moreover, a single point-in-time measurement of sanitation conditions could not control for seasonal variability. Digital channels may have excluded important voices (those without access to the internet, smartphones or the skills needed to use them), and the participatory mapping approach required close attention to the way in which local power relations could bias our results. Asking participants for their opinions on the quality of their experience required careful attention to data privacy concerns and the evidence we collected from Adukrom cannot automatically be generalized to other communities in Ghana. Lastly, we stated explicitly that these measures of desired changes are not tantamount to behavior change.

Recommendations

We recommend that sanitation monitoring draw from all sources of information available, including direct observation in the field, service data, reports from the public, and spatial data to provide an explicit understanding of where services exist or do not exist, which can be updated regularly as conditions change. Community leaders should be engaged as partners in collecting and using feedback as feedback givers, not as feedback transmitters. Waste management providers must communicate equitably and transparently based on sets of performance criteria such as when they service, how far their services extend, and how to lodge complaints and have them addressed. Community-based and non-governmental organizations are essential providers of independent feedback and must be mobilized to conduct participatory mapping, targeting the most marginalized, to increase accountability. Frequency-limited campaigns should link the actual condition of the environment to the specific behaviors that will best mitigate the risk to public health by exploring audience activism preferences, levels of trust, and the behaviors that would be difficult for them to adopt. Our protocol established clear causal hypotheses, but we recommend future studies use longitudinal or quasi-experimental designs to test some of these beyond the immediate study conditions.

Desk Review of Secondary Statistical and Geospatial Data Sources

The first task after defining the problem is to assemble all the secondary data that is available. Both the statistical and geographic data acquired during this phase must be thoroughly evaluated in terms of source and currency to determine their fitness for inclusion in the sampling frame or in the spatial analysis. In the Statistical Data section, recent official census reports must be searched for demographic and hygiene-indicator information to determine whether feasible

indicators can be defined. In the Geographic Data section, the national geoportal must be reviewed to assess the datasets associated with administrative areas, roads, health hygiene, and facilities. All layers that are not current must be flagged for acquisition or field data collection. The status of the computation of the sampling frame and the availability of demographic and hygiene indicators from the census are reported in the Data-Revisit section. The status of the acquisition of a geodatabase that will support spatial analyses is described in the Geodatabase section, including details regarding specific datasets that have been acquired or confirmed.

Consolidated Assessment of the Secondary Data Landscape

The sources for the demographic and sanitation indicators needed in our study of the PHC 2021 are the most authoritative for such matters in Ghana. As the Ghana Statistical Service (GSS, 2021) [17] describes, the "General Report" series of the 2021 Population and Housing Census (PHC) provides the required information. The relevant volumes are Volume 3A: Population of Regions and Districts (GSS, 2021) [17]; Volume 3B: Age and Sex Profile; Volume 3K: Housing Characteristics; and Volume 3M: Water and Sanitation (GSS, 2022) [18]. These volumes contain the counts needed for the totals at locality and district level, such as population and number of households, average household size, sex and age structure, and urban-rural classification. They also provide data on the type of toilet facilities and waste disposal method, thus allowing for the sanitation indicators and the solid waste disposal indicators to be identified without the requirement of any other census product. At the same time, the review established that the specific locality- and district-level numeric tables for Adukrom and Okere District were not accessible within the available results.

As a result, the data for the total population of Adukrom locality, the total population of Okere District, the number of households in Adukrom, the average household size, sex and age distribution, urban or rural classification, types of toilet facilities, and waste disposal methods are still unavailable at this point. This outcome has a direct and traceable consequence for the study's sampling design: because the household count N for Adukrom is unavailable, the finite-population correction $n = n_0/(1 + (n_0 - 1)/N)$ cannot be evaluated, and the household sampling frame for Adukrom cannot yet be constructed. The initial Cochran sample size $n_0 = Z^2p(1-p)/e^2$ is itself computable only once the confidence level (and hence Z), the expected proportion p, and the margin of error e are specified; the corrected sample size n additionally requires N. The dependency structure of this computation is summarized in Table 2. A further methodological safeguard emerged from the review: any population figure for Adukrom or Okere District dating from before 2021 should be treated as provisional and flagged for field verification rather than adopted directly into the sampling frame.

Table 2: Dependency structure of the sample-size computation

Quantity	Symbol	Required inputs	Status
Initial Cochran sample size	n_0	Z, p, e	Computable once parameters are specified
Finite-population correction	n	n_0, N	Blocked pending household count
Household count for Adukrom	N	Locality-level census extract	Unretrieved

As a first step in the geodatabase construction, the open dataset layers were downloaded from the Ghana Open Data Initiative portal (Ghana Open Data Initiative, n.d.; see Ohemeng & Ofosu-Adarkwa, 2015, for an assessment of the initiative) [27], which hosts the core boundary and road network layers used in this study. The initially downloaded dataset consisted of a shapefile of ten regional boundaries for Ghana. The shapefile of district boundaries had both 170-district and 216-district versions to permit analysis for various designs. The road data include the Ghana feeder roads, Greater Accra Metropolitan Area roads, and urban road class layers. These layers serve to clip the boundary layer to Okere and overlay the facility points with service areas, and they are also suitable for the preliminary geodatabase construction required to answer the first and fourth research questions. It should also be noted that while the portal results suggest that a locality or community-level boundary might exist for Adukrom, one was not found. Therefore, a finer administrative-level source must be relied upon to construct a polygon separating this locality from others. Similarly, in terms of the overlays and subsequent accessibility analyses, it was not possible to locate the point layer for sanitation facilities or the service-zone layer. These results are summarized in Table 3.

Table 3: Confirmed availability status of geospatial dataset types

Dataset type	Availability	Implication for the protocol
Regional boundary (10-region shapefile)	Confirmed	Supports district clipping and base mapping
District boundary (170- and 216-district versions)	Confirmed	Enables selection of administrative vintage
Road network (feeder, GAMA, urban class)	Confirmed	Enables shortest-path and accessibility analysis
Adukrom locality boundary	Not confirmed	Must be derived from finer administrative source
Sanitation facility points	Not confirmed	Must be generated or sourced separately
Sanitation service zones	Not confirmed	Must be generated or sourced separately

With respect to the input data needed for the geodatabase, the following dataset sources can be confirmed as ready for acquisition and analysis: statistical data, spatial boundary data, and road data. However, the numeric data components of the statistical datasets and the layers for locality boundaries and sanitation facility locations are still outstanding. The assessment of confirmed and outstanding datasets can now evaluate the feasibility of sampling computation and geodatabase construction, as the outstanding components serve as the gating variables in the protocol. While these steps

are still outstanding, the protocol can still be considered as feasible overall.

Inventory of Confirmed and Unconfirmed Geospatial Datasets

The data presented in Table 4 was drawn from the source results of our findings. This table contains a summary of the availability findings of each identified geospatial dataset examined. The status of each dataset was determined based on the search results from the Open Data Initiative portal site, and the table summarizes each data format field into two categories: "yes" for confirmed and "no" for not confirmed datasets. Furthermore, the table identifies the availability or form of the respective confirmed datasets.

Table 4: Availability status of geospatial datasets on the Ghana Open Data Initiative portal

Dataset type	Confirmed availability	Notes
Regional boundaries	Yes	10-region shapefile available (Ghana Open Data Initiative, n.d.)
District boundaries	Yes	170-district and 216-district versions available (Ghana Open Data Initiative, n.d.)
Road network	Yes	Ghana feeder roads, GAMA roads, and urban road class layers are available (Ghana Open Data Initiative, n.d.)
National boundary	Not confirmed	Not explicitly verified in the returned portal results
Locality/community boundary	Not confirmed	Adukrom-level boundary not explicitly verified
Facility points	Not confirmed	No directly verified sanitation facility layer in results
Service zones	Not confirmed	No directly verified service-zone layer in results

It is clear from the information in Table 4 that the layers of data available from the portal contain confirmed data for the regional, district, and network scales. However, layers at the locality and facility scales still need to be confirmed. In general, this indicates that the portal primarily supports meso-scale and macro-scaling assessments of infrastructure and administrative geometry; it is less clear whether this structure can support locality-scale service delivery analysis. It is clear from the results of Table 4 that topographic-level clipping of Adukrom's district would work well with the confirmed data; with a suitable road network in hand, analyses of accessibility are immediately ready to go forward, thus enabling answers to the first and fourth of the research questions set out above. To explore accessibility at district or network scales, however, a suitable road network must be available. In the data that are confirmed, road layers exist with which to conduct shortest-path and accessibility analysis. This is important, as it means that the first and fourth research questions can be addressed. Importantly, with appropriate feeder roads, GAMA roads, and urban road classes within the confirmed road layer, a certain degree of flexibility exists in the ability to characterize Adukrom as a settlement with direct reference to its network. Upon entering the layers into the geodatabase, it is vital to create an explicit record of their provenance attributes; for example, the information about the district boundary should contain tags describing it as 2021 vintage with geographic coordinates based on the WGS 84 datum (EPSG:4326).

This is necessary to synchronize with the era of the administrative boundaries used with the Okere clip and the demographic review. Additionally, the drainage lines derived from the 2023 high-resolution satellite images must include a record indicating that they were projected onto the Ghana National Grid (EPSG:2136) to ensure that distance calculations are performed in a linear projected unit instead of decimal degrees (EPSG:2136 uses Gold Coast feet, which must be converted to meters where metric distances are required; EPSG Geodetic Parameter Dataset, n.d.), which is an inappropriate unit for accurately interpreting Euclidean distances, much less network distances, in any degree-based context. Such distance work is meaningless as describing accessibility burdens if dimensionless projections have been allowed to proliferate. The review showed that all records received from the Okere District Assembly have been requested, so that information was obtained on the locations of public latrines and the routes for waste collection. The completeness of the records is unknown, and their positioning cannot be verified, so these layers represent candidate inputs for the facilities and service areas, rather than confirmed inputs. Other layers that require verification, like buffering and accessibility analyses, also need to have field verification for spatial reliability. To help avoid mistakes in subsequent analyses, each retained layer includes the source and date of acquisition and a statement regarding its source for coordinates. Layers that are not confirmed are not used as authoritative sources in final analysis.

Status of the Sampling-Frame Computation and Census Indicator Extraction

Table 5 presents the extraction status of each requested census indicator alongside the computational status of the Cochran sample-size formula and its finite-population correction. The table makes explicit the dependency of the corrected sample size n on the household count N, and it records the pre-2021 verification flag that applies to any older population figures encountered during the review.

Table 5: Extraction and computation status for census indicators and sample-size estimation

Item	Requested output	Status
Adukrom locality total population	Population count	Not retrievable from available results
Okere District total population	Population count	Not retrievable from available results
Number of households in Adukrom	Household count	Not retrievable from available results
Average household size	Average persons per household	Not retrievable from available results
Sex/age structure	Age-sex distribution	Not retrievable from available results
Urban/rural classification	Urban or rural locality status	Not retrievable from available results
Toilet type	Sanitation indicator	Not retrievable from available results
Waste disposal method	Solid waste indicator	Not retrievable from available results
N (Households in Adukrom)	Finite-population parameter	Not available
n_0 (Cochran initial sample)	Initial sample size	Computable only if Z, p, and e are specified
n (Corrected sample)	Final sample size	Cannot be computed without N
Pre-2021 population figures	Cross-check input	For field verification only

The computational logic underlying Table 5 can be stated compactly. The initial sample size follows the Cochran formula (Cochran, 1977) [10], $n_0 = Z^2 p(1-p)/e^2$, and the finite-population correction is $n = n_0/(1 + (n_0 - 1)/N)$, where N is the number of households in Adukrom. The review confirmed that N is the binding constraint: without it, neither the corrected sample size nor the household sampling frame can be finalized. The table also records the cross-check provision that any pre-2021 population figure should be treated as subject to field verification, which preserves the integrity of the sampling frame against the use of outdated denominators. Now consider the missing indicators in the order of their effect on the survey. First of all, some of them provide only descriptive information regarding sanitation and will not affect the determination of sample size. The toilet type indicator and any other indicator related to waste disposal, whether it is present or missing in the data file, will only provide information for the profile. Such indicators can be used as contextual variables for any form of sanitation visit, whether sample/complete without affecting sample size consideration. If indicators of this type are missing, the descriptive aspect of the survey may be delayed, but the sampling design will not be delayed. This is not true of other indicators, notably the number of households in the survey area, N.

The character of the survey, which is substantially influenced by the finite population correction, estimation of stratum memberships, and the walking order in systematic sampling, depends on N. There is no parallel here between the case of n_0 and n. The need for n is dependent on n being empirically determined, and until it has been determined, the sample cannot be defined. No part of n_0 is so dependent. After the investigator selects the confidence level and the expected proportion and margin of error, n_0 is determined. We must therefore proceed to advance work on the missing indicators that seem to be critical in establishing the sample size in the full light of this understanding. It might be tempting to use the PHC population of the entire Okere District for 2021 in place of the Adukrom figure. This only serves to emphasize the fact that special care is needed in determining the value of the total population figure N. If one uses a different population base, the effect of this substitution should normally be to increase the value of N by an unknown proportion, which will then also have the effect of decreasing the finite population correction term within the sampling error expression virtually to zero. The only acceptable population base for the Adukrom locality is that extracted from the census tables, which means that if those census tables do not provide such an extract directly, it must be obtained by going to the field and enumerating the number of households in the locality.

Geodatabase Construction Workflow and Its Confirmed Inputs

The preliminary geodatabase was then created following the input described above and assessed in terms of the confirmed data layers listed in Table 4. First, the regional boundaries shapefile selected to define the study area should be downloaded along with a boundary's shapefile at the study level of interest (170-district level or 216-district level; Ghana Open Data Initiative, 2026) [16]. Next, road files for evaluating accessibility and pathfinding (Ghana Open Data Initiative, n.d.) should also be downloaded. The district layer was then clipped to the Okere district, with Adukrom's locality polygon extracted/derived from finer administrative boundaries. The facility points and service zone layers were downloaded and overlaid over the administrative base. The preliminary geodatabase was then created along with performing short-path and accessibility analyses of sanitation facilities over the road network. Figure 1 provides subsequent workflow steps with regard to remaining layers that require confirmation.

The phasing issue for our three types of input is well illustrated by our neophyte experience with our geodatabase. There is an asymmetry between the backbone layers and the more numerous facility layers: some of the spatial data were readily available, while others had to be awaited. The regional boundary, the district boundary, and the network of roads were all confirmed spatial data that were available and thus not pending. Just before the geodatabase was to be created, we had confirmed the clipping step that would prepare the district boundary for use with the Okere spatial data, but the remainder of those three inputs, the locality polygon, the facility points layers, and the service zones, were all still pending. We proceeded immediately to instantiate the geodatabase with the confirmed backbone layers (and the clipping step). In this way, we could concentrate on exploring, testing, and documenting our assumptions with respect to establishing the conventions for coordinate references and metadata before being distracted by the excess of uncertainty with the facility-scale data still pending. The road network is a key layer for this analysis, as it offers the functionality of a shortest-path and accessibility

layer as required to answer the first and fourth research questions. Depending on the nature of settlements within Adukrom, each of these three different road layers is evaluated to figure out which one has the greater degree of completeness and topological validity, not only the one that makes the overlay less complex.

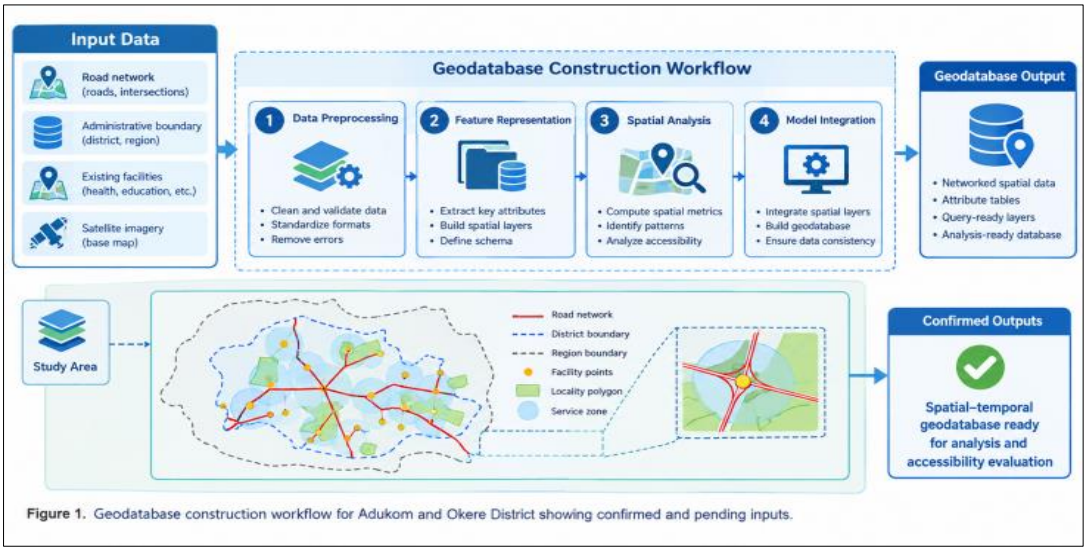


Fig 1: Geodatabase construction workflow for Adukrom and Okere District showing confirmed and pending inputs

Likewise, modifications to the raster base of this study are achieved by employing various iterations of district boundaries. The district boundary that corresponds best to the nature of sampling, reporting, and enumeration areas is used for the cut-out Adukrom sample, referred to as Okere, of the 2021 district boundary variant imported as WGS 84 [EPSG:4326]. The digitized drainage formations, in conjunction with their accompanying attribute data extracted from 2023 satellite imagery, are in their final form when they too are projected to the Ghana National Grid [EPSG:2136]. The portal shows that confirmed inputs mark the boundaries of the analysis. There is no confirmed locality or community boundary for Adukrom. This means that the geometry for the locality must originate elsewhere in an administrative source that represents the area at a finer scale. Similarly, there is not a sanitation facility or service zone layer to query. This means that the analysis will have to await collections of either GPS points in the field or the use of unverified information from the Okere District Assembly. Again, until those layers can be added, there is no opportunity to continue with the overlaying and accessibility modeling processes. Therefore, the class ends after this step with a preliminary geodatabase, but no final accessibility surfaces.

Discussion: Integrating Spatial Evidence, Communication, and Participation

We wish to emphasize that the integration of spatial evidence, communication, and citizen participation should not be reduced merely to a methodological convenience. Rather, it must be treated as a proposition to govern successfully. Obstacles to effective sanitation governance cannot be understood unless spatial inequalities point out an answer to some significant question. Limiting attention solely to service availability and the physical state of facilities would not suffice, but you cannot treat spatial mapping as an end in itself either. A concentration of solid waste disposal at one location could result from the absence of community containers, the poor condition of the drainage, the rubbish collection route, or the socioeconomic background of residents. All of these explanations could be true, but they must be recognized as more than research curiosities. Triangulation can help to validate or contrast institutional narratives against what citizens report and what is evident in the field. In that regard, spatial evidence can be reflected back at governance questions regarding who receives sanitation service, who suffers the public health consequences, and who participates in decision-making. Remember that there is a distinction between information or consultation, which is tokenism in Arnstein's (1969) [6] classification, and true decision-making power. Consistent receipt of information throughout a campaign does not constitute partnership in governance if the individual citizen was not involved, for example, in determining when sampling would occur or where facilities would be located.

This is the distinction that can be drawn from a picture such as this, particularly when the difference is fleshed out with Likert-type measures of opportunities to provide feedback and perceived agency. Likewise, the measures derived from the theory of planned behavior, such as attitudes, subjective norms, and perceptions of control, exert their influence through their joint contribution to forming behavioral intention (Ajzen, 1991) [3]. If there are suggestive correlations between quality of communication and level of participation, it does not necessarily follow that communication was the driving force behind the behavior. A cross-sectional study design (which represents the ones generally employed) prohibits inferring a causal chain from communication to behavior. If residents are not getting messages of some type, the question now becomes why this is happening. This may stem from insufficient information or inadequate communication channels, a lack of trust in the existing channels or messengers, or potential language barriers, among other factors. Conversely, the quality rating might indicate that respondents feel that feedback mechanisms are weak or that there is insufficient responsiveness by these systems. Each explanation has different practical implications for remedial action. If channel problems exist, for example, radio or WhatsApp might be more effective for

promotion than community meetings. If credibility issues are more pertinent, district officials could have less influence, and traditional leaders or religious institutions might be more credible. In all these scenarios, however, it is clear that a composite communication-quality index might obscure the level of interest and be less useful than the various disaggregated measures described earlier.

Moreover, alongside the inconsistent delivery of water supply, sanitation services may also exhibit notable disparities in the locations where they are offered. As it is often easier to provide services as you get nearer to main roads or routes followed for collection services, peripheral areas may be served less frequently. This differential delivery may not be associated with any specific disease occurrence but can create great environmental health risks. On the positive side, GIS can be introduced into the routine sanitation planning process of individual districts by constructing protocol methodologies that include the introduction of this spatial information. As is the case when strategic communication methods are used to create dialogue rather than to justify pre-ordained decisions, such protocol methodologies require co-construction of the information with residents in a way that will expose them to the ways in which spatial data must guide the priorities selected for specific interventions, as well as help to explain and rationalize the various arrangements selected for execution. Such protocol methodologies could start to demonstrate the ways in which both spatial analysis and resident interpretation of information can enhance much-needed communications in the process of defining priorities for sanitation interventions. Finally, GIS methods can be linked with others using participatory mapping to guide analysis from a community perspective.

Conclusion

The present study contributes with a conceptual framework and methodological guide to enhancing community participation in environmental sanitation in Adukrom, Ghana, by linking geo-information with strategic communication. The research describes the experimentation with quantitative and qualitative methods used to address the two research questions. Various types of research will help triangulate information to arrive at reliable, valid conclusions. The use of household surveys, key informant interviews, focus groups, geo-referencing sanitation mapping with GPS, and participatory GIS is integrated in a convergent design. This entails the possibility of advancing relations among geo-information, Father, and local people. For example, within participatory communication theory, it is essential that communication has a dialogic character and that local people and their social structure are truly respected through local knowledge and participation. Subsequent to data triangulation, geo-information can also serve as a medium of communication that stimulates local people's participation in environmental sanitation. This is consistent with Arnstein's ladder of citizen participation, which distinguishes between informing, consulting, and (going further up the rungs) the provision of 'plenty of opportunities for active participation by citizens. By means of the Theory of Planned Behavior, the explanation of the latter is based in Part II on the determinants of people's attitudes, subjective norms, perceived behavioral control, and intentions towards behavior. Part III describes the development and analysis of the data integration, which provides a central contribution in the methodological sense. The results of the different data integrations can be interpreted with reference to the qualitative aspects of the geo-information and strategic communication processes described in these parts. Geo-information is constructed and analyzed according to what is available. Spatial analyses will logically depend on the availability of a geodatabase on which the boundary and road network layers must be based. In the protocol, nothing is said about this because it certainly exists in the geo-information but may not yet be available. As said above, the census extractions for the case study areas and sanitation facilities have not yet been available when this technical protocol was written. This desk review outlines the necessary next steps for implementing the Adukrom protocol. However, it is important to note that a thorough assessment of sanitation conditions and the level of community participation in Adukrom can only be achieved through actual data collection and analysis. It is important to note that the current level of generalization concerning communication quality, spatial service patterns, and participation is merely suggestive rather than definitive. In order to complete the protocol, it will be necessary first to complete the extraction of the census data from the Ministry of Information and collect additional data on the location and service patterns of functional facilities. The ultimate goal of the protocol is first to test whether effects on participation and equity can be enhanced. Second, in order to strengthen the protocol, the issues related to scale and data density should be assessed. The latter involves the feasibility of undertaking investigations like those in Adukrom in other district capitals where spatial information acquisition is equally uneven.

References

1. Abalo EM, Agyemang S, Atio S, Ofosu-Bosompem D, Peprah P, Ampomah-Sarpong R. Environmental sanitation unleashed: Effectiveness and challenges of the National Sanitation Day as a community sanitation participatory approach in Aboabo, Ghana. Cogent Environmental Science. 2017;3(1):1405888. doi:10.1080/23311843.2017.1405888
2. Adorsu-Djentuh FY. Implementation of environmental sanitation policies: Assessing the role of local actors in Ghana [Doctoral dissertation, University of Manchester]. University of Manchester Research Explorer; 2018. Available from: https://research.manchester.ac.uk/en/studentTheses/implementation-of-environmental-sanitation-policies-assessing-the/
3. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991;50(2):179-211. doi:10.1016/0749-5978(91)90020-T
4. Althubaiti A. Information bias in health research: Definition, pitfalls, and adjustment methods. Journal of Multidisciplinary Healthcare. 2016;9:211-217. doi:10.2147/JMDH.S104807
5. Apparicio P, Abdelmajid M, Riva M, Shearmur R. Comparing alternative approaches to measuring the

geographical accessibility of urban health services: Distance types and aggregation-error issues. International Journal of Health Geographics. 2008;7:7. doi:10.1186/1476-072X-7-7
6. Arnstein SR. A ladder of citizen participation. Journal of the American Institute of Planners. 1969;35(4):216-224. doi:10.1080/01944366908977225
7. Asokwah GA, Gyamfi GO, Abubakari MA. The water and sanitation sector of Ghana—What is missing from a governance perspective? Water Policy. 2026;28(7):1036-1061. doi:10.2166/wp.2026.169
8. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006;3(2):77-101. doi:10.1191/1478088706qp063oa
9. Brewer T. Environmental sanitation provision among women with children in Kumasi, Ghana [Doctoral dissertation, Loughborough University]. Loughborough University Research Repository; 2022. Available from: https://repository.lboro.ac.uk/Architecture_Building_and_Civil_Engineering_Theses/categories/Built_environment_and_design/31646
10. Cochran WG. Sampling techniques (3rd ed.). John Wiley & Sons; 1977.
11. Doku DT, Nartey YA, Cudjoe O, Sakyi GA, Duah E, Adjei G, *et al*. A scoping review of the health and health-related sustainable development goals (HHSDGs) in Ghana: Progress and challenges. BMC Public Health. 2026;26:584. doi:10.1186/s12889-025-25985-y
12. Dreibelbis R, Winch PJ, Leontsini E, Hulland KRS, Ram PK, Unicomb L, *et al*. The Integrated Behavioural Model for Water, Sanitation, and Hygiene: A systematic review of behavioural models and a framework for designing and evaluating behaviour change interventions in infrastructure-restricted settings. BMC Public Health. 2013;13:1015. doi:10.1186/1471-2458-13-1015
13. EPSG Geodetic Parameter Dataset. EPSG:2136 – Accra / Ghana National Grid [Coordinate reference system]. International Association of Oil & Gas Producers; [date unknown]. Available from: https://epsg.io/2136
14. Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs—Principles and practices. *Health Services Research*, *48*(6, Pt. 2), 2134–2156. https://doi.org/10.1111/1475-6773.12117
15. Getis A, Ord JK. The analysis of spatial association by use of distance statistics. Geographical Analysis. 1992;24(3):189-206. doi:10.1111/j.1538-4632.1992.tb00261.x
16. Ghana Open Data Initiative. Ghana Open Data Initiative portal [Data portal], from. [date unknown]. Available from: https://data.gov.gh [cited November 1, 2026]
17. Ghana Statistical Service. 2021 population and housing census: General report: Vol. 3A. Population of regions and districts; 2021. Available from: https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/2021%20PHC%20General%20Report%20Vol%203A_Population%20of%20Regions%20and%20Districts_181121.pdf
18. Ghana Statistical Service. 2021 population and housing census: General report: Vol. 3M. Water and sanitation; 2022. Available from: https://census2021.statsghana.gov.gh/gssmain/fileUpload/reportthemesub/Volume%203M_Water%20and%20Sanitation_240222a.pdf
19. Gohoho M, Bosoka SA, Agyemang GS, Ziema SA, Alorwu J, Ahmed H, *et al*. Risk factors for Buruli ulcer disease in Ghana: A matched case-control study in four selected endemic districts of Eastern and Oti Regions. PLOS Neglected Tropical Diseases. 2025;19(11):e0013684. doi:10.1371/journal.pntd.0013684
20. Knierzinger J. Chieftaincy and Development in Ghana. From Political Intermediaries to Neotraditional Development Brokers: Working Papers of the Department of Anthropology and African Studies of the Johannes Gutenberg University Mainz. 2011;124. Available from: https://ucrisportal.univie.ac.at/de/publications/chieftaincy-and-development-in-ghana-from-political-intermediarie/
21. Kosoe EA, Ahmed A. Drivers of ineffective environmental sanitation bye-laws in Ghana: Implications for environmental governance. Urban Governance. 2024;4(1):16-24. doi:10.1016/j.ugj.2023.09.004
22. Marondedze AK, Mutanga O, Cho MA. Promoting inclusion in urban land use planning using participatory geographic information system (PGIS) techniques: A systematic review. Journal of Environmental Management. 2024;370:123099. doi:10.1016/j.jenvman.2024.123099
23. McCall MK. Seeking good governance in participatory-GIS: A review of processes and governance dimensions in applying GIS to participatory spatial planning. Habitat International. 2003;27(4):549-573. doi:10.1016/S0197-3975(03)00005-5
24. McCall MK, Minang PA. Assessing participatory GIS for community-based natural resource management: Claiming community forests in Cameroon. The Geographical Journal. 2005;171(4):340-356. doi:10.1111/j.1475-4959.2005.00173.x
25. McKenzie-Mohr D. Fostering sustainable behavior through community-based social marketing. American Psychologist. 2000;55(5):531-537. doi:10.1037/0003-066X.55.5.531
26. Ntassiou K. Participating in rural appraisal? A review of participatory GIS and citizen science approaches. Geography Compass. 2025;19(3):e70023. doi:10.1111/gec3.70023
27. Ohemeng FLK, Ofosu-Adarkwa K. One way traffic: The open data initiative project and the need for an effective demand side initiative in Ghana. Government Information Quarterly. 2015;32(4):419-428. doi:10.1016/j.giq.2015.07.005
28. Okere District Assembly. District profile and 2025 composite annual action plan. 2024. Available from: https://okda.gov.gh/wp-content/uploads/2026/03/OkDA-2025-Composite-APP.pdf
29. Otto H, Fourie LM. Theorising participation as communicative action for development and social change. Communicare: Journal for Communication

Studies in Africa. 2016;35(1):21-39. doi:10.10520/EJC195359
30. Sieber RE. Public participation geographic information systems: A literature review and framework. Annals of the Association of American Geographers. 2006;96(3):491-507. doi:10.1111/j.1467-8306.2006.00702.x
31. Tufte T, Mefalopulos P. Participatory communication: A practical guide. World Bank; 2009. Available from: https://openknowledge.worldbank.org/handle/10986/5940

How to Cite This Article
Edna B. Integrating geo-information science and strategic communication to strengthen community participation in environmental sanitation: a mixed-methods participatory research protocol for Adukrom, Ghana. International Journal of Humanities and Sustainable Innovation. 2026;2(6):31-44. doi:10.54660/.IJHSI.2026.2.6.31-44.

Creative Commons (CC) License
This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.