Assessing the state, impact, and sustainability of the Vunania and Gia reservoirs in the Kassena Nankana Municipal of the Upper East Region

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List of Acronyms

LIPW	Labour Intensive Public Works
GSOP	Ghana Social Opportunity Project
MDCE	Municipal and District Chief Executive
GIDA	Ghana Irrigation Development Authority
SMCD	Supreme Military Council Decree
MoFA	Ministry of Food and Agriculture
FAO	Food and Agriculture Organization
IFAD,	International Fund for Agricultural Development
UWADEP	Upper West Agricultural Development Project
LACOSREP	Land Conservation and Smallholder Rehabilitation Projects
VIP	Village Infrastructure Project
IWMI	International Water Management Institute
NGOs	Non Governmental Organizations
lV1D	One Village One Dam
FG	Focal Group
LPSCU	Land Planning and Soil Conservation Unit
PFAG	Peasant Farmers Association of Ghana
GIMPA	Ghana Institute of Management and Public Administration
FSL	Full Supply Level

Abstract

The northern regions of Ghana are characterized by a unimodal rainfall pattern, making rain-fed agriculture an unreliable venture. One way out of this constraint is the construction of reservoirs to capture flash floods in the rainy season for irrigation purposes in the dry season. Although previous studies have examined various aspects of reservoirs, there remains a gaping hole in the holistic research evaluation of newer projects**.** This study examined the state, impact, and sustainability of the Vunania dam constructed and funded by the World Bank, and the Gia dam under the One Village One Dam [1V1D] policy. The comparative analysis provides empirical evidence to inform policy direction. Using a qualitative research approach via site visits, focus group discussions, expert interviews, and informal conversations, the study uncovers that the Vunania reservoir was birthed out of a cooperative farming enterprise that existed between the department of agriculture and community members between 1950 and early 1960s. It stalled in the aftermath of the 1966 coup and has been revived. Among others, this is a very viable community-driven intervention that has the potential to alleviate poverty through sustainable farming, aquaculture, animal husbandry, and all-year-round agriculture in the community. Although community members are very excited and have started benefiting from the infrastructure, there is a lingering fear that the intervention may not yield the needed results sustainably due to lapses observed shortly after the construction of the dam; these include leakage, low embankment height, and high spillway elevation. The evidence emerging from the Gia reservoir indicates that the intended objectives and the actual construction are far apart. The storage capacity is too small, the valley is very flat and the dam wall is not engineered. This is because the collaborative effort required by all stakeholders in the conceptualization, design, and construction suffered a setback. This has subsequently reduced the dam to livestock watering only.

Despite the teething problems identified, it cannot be ignored that interventions such as small-scale dams are the way to go for northern Ghana. Therefore, attending to the initial hurdles in these early days could save substantial public resources from going down the drain while at the same time providing real solutions to the main bottleneck to sustainable farming in Northern Ghana. To this end, a re-engineering of the Vunania dam to increase its capacity and correcting of the defects of the dam wall and lapses in the irrigable is highly recommended. A uniform excavation of the Gia reservoir to the deepest depth to create room for more water to be stored can potentially increase its usefulness to farmers in the community while engaging the local people and roping in the stakeholders would ensure judicious use of public funds. These two examples, when properly revived could signal a return to all-year farming in the communities of the Kassena Nankana Municipal and open doors for the replication of similar projects to arrest the declining state of agriculture in the savannah regions of Ghana. For this to take root, a round management structure involving the local leaders, the beneficiaries, and the district Assembly with clear oversight responsibility and persistent checks and balances to ensure proper use and maintenance of the reservoirs could create a good platform for managing water resources and provide an effective means of local problem solving and skills development.

1. Introduction and Literature Review

1.1 Irrigation Development in Ghana

Small-scale earth dams for farming have been part of the Ghanaian agricultural system, especially in the drier parts of the country since time immemorial. However, a more organised system of irrigation dates to the period just before independence, picked up in the 1960s and further accelerated under the Land Planning and Soil Conservation Unit of the Ministry of Agriculture. Following Ghana's independence in the 1950s, the priority of water infrastructure development was towards large-scale dams for large- scale irrigation (Venot et al., 2011). The Asutsuare and the Dawenhya dams were among the first to be constructed with irrigation infrastructure after independence (Kyei-Baffour and Ofori, 2007). In 1977, the Ghana Irrigation Development Authority was established by The Supreme Military Council Decree 89 (SMCD) to oversee the development of irrigation infrastructure (GIDA, 2012). The Ghana Irrigation Development Authority has been at the forefront of developing irrigation infrastructure through the exploration of water resources for livelihood options in agriculture at appropriate scales for all communities.

Generally, large-scale irrigation infrastructure has received huge public investments in the developing world post-1960s (Jones, 1995). While these investments have yielded significant impacts in improving food security and poverty reduction in most parts of Asia, the same cannot be said of sub-Saharan Africa (Rosegrant *et al*., 2001; Hussain, 2005). Large-scale irrigation schemes in Africa are publicly managed and farmers are mostly the receivers of unfair decisions made by management, which impoverish rather than enrich indigenous farmers (Williams, 2007). Paradoxically, the staff of the project tends to meet their own needs and those of influential strangers with lands in the project's site first. Thus, enrichment from corruption does not end with the construction of reservoirs but extends to local irrigation officials (Rijsberman, 2005). This has sometimes led to conflicts between farmers and management. Furthermore, concerns over negative social impacts have also been raised over large reservoirs as they cover a greater area. These include the displacement of residents in affected communities and lack of compensation for the lands confiscated. An example is the case of the Vea scheme in the Upper East Region (Konings, 1986). Moreover, large-scale irrigation schemes in sub-Saharan Africa have underperformed resulting in a lack of further investment in large-scale irrigation infrastructure (Chambers 1988; Merrey, 1997). Data from FAO, (2005) shows that the underutilization of large-scale irrigation schemes in sub-Saharan Africa is about 18%. This means that on average, about 82% of developed hectares in large-scale irrigation schemes are utilized. In addition to the underutilization of developed large- scale irrigation areas (FAO, 2005), revenue has, neither fully recouped the high investment costs nor the operations and maintenance costs of large irrigation infrastructure in most cases (Diemer, 1988; Faures *et al.,* 2007). This has generated debates on whether investing in large-scale irrigation infrastructure is worthwhile for irrigation development in sub-Saharan Africa (Wallace, 1979; Williams, 2007). Specifically, evidence in Ghana shows that poor management and operation challenges have limited the contribution of these irrigation schemes to livelihoods and economic development (Acheampong *et al.,* 2014). In a nutshell, the high cost of construction, underutilization, and management challenges as well as the negative social impacts often put a big question mark behind the economic viability of large reservoirs for large-scale irrigation schemes (Diemer, 1988).

The fact remains that water infrastructure is still needed to safeguard people's livelihoods and the environment (Kijne *et al.,* 2003, 2009; Faures and Santini, 2008), particularly in Northern Ghana where rainfall pattern is unimodal and unpredictable (Barry *et al.,* 2005). Hence, the challenges associated with large-scale irrigation projects resulted in a gradual shift towards the development of small-scale irrigation infrastructure such as small reservoirs. The special appeal of small reservoirs is that their construction requires comparably little expenditure and represents an adequate tool to manage freshwater storage. Furthermore, the construction of small reservoirs in larger numbers and well spread throughout a region reaches a wide population and facilitates its water demands (Liebe, 2002). Small reservoirs and other small-scale irrigation technologies (shallow wells and riverine alluvial dugouts) are better managed due to their relatively small farm size, resulting in high crop yields and also involving a higher women participation (Ofosu, 2012). Most importantly, the heightened interest in small water storage technologies is because indigenous farmers have full control over the water, and the irrigation schemes are fully managed by them. Falkenrnark and Rockstrorn (2004) and Polak (2005) believe that making widely available relatively low-cost agriculture water management technologies such as small reservoirs and dugouts can make a major contribution to rural livelihoods, hence should be preferred.

Between the late 1950s and early 1970s, the demand for water to meet irrigation and livestock water needs in the dry season triggered the construction of about 240 earth dams and dugouts in Northern Ghana (Agodzo and Bobobee, 1994). IFAD, (2005) reported that there are about 156 small reservoirs and dugouts in the Upper East Region of Ghana alone (IFAD, 2005). By the year 2008, there were about 3,392 small dams and dugouts serving about 6,000ha across Ghana. Out of this number, about 149 small dams and 129 dugouts are located in the Upper East Region (Namara et al., 2011). The development of dugouts has been concurrent with the development of small reservoirs in Ghana. The main distinguishing feature between dugouts and small reservoirs is that while small reservoirs are constructed in the stream channel, dugouts are constructed in the flood plains of the stream and are fed by surface water in the flood plains. Dugouts are much smaller, but one thing is common among dugouts and dams and that is they both store water for use in the dry season. Data compiled by GIDA shows that currently there are about 168 dams and 153 dugouts in the Upper East Region alone. By 2003, there were over 850 dams and dugouts in the Northern and Upper East Regions of Ghana (Kyei-Baffour and Ofori, 2007). From the 1990s' investments in the construction of small reservoirs and dugouts in Ghana have largely been donor-driven among which are, World Bank Village Infrastructure Project (VIP), International Fund for Agricultural Development (IFAD) Upper West Agricultural Development Project (UWADEP) and Land Conservation and Smallholder Rehabilitation Projects (LACOSREP) 1 and 2.

Although these small reservoirs and dugouts have been reported to have contributed significantly to the reduction of seasonal migration and poverty as well as aiding in the production of relatively cheap food for everyone (Akidugu *et al*., 2016; Adam *et al.*, 2016), not all of them remain functional. The engineers often attribute this to a lack of experience and interest of farmers to maintain the irrigation infrastructure. During the 1980s, it was realized otherwise that the problems with small-sized irrigation schemes were attributable to the fact that the indigenous knowledge of the farmers was not considered (World Bank, 1986; GIDA, 2010). In addition, the local economic, social, and cultural contexts of beneficiary communities had not been considered in designing the systems. As a result, the FAO, World Bank, and *IWMI* from the 1990s started investing in the rehabilitation of existing small reservoir systems and in improving their maintenance and operations. For example, 100 small reservoirs have been rehabilitated by IFAD under Phase I and II of the *Upper East Land Conservation and Rehabilitation Project (LACOSREP) in the Upper East Region of Ghana since 1990 (IFAD, 1990).* Thus, 64 reservoirs were rehabilitated under Phase 1 and 36 under Phase II (IFAD, 2005). Low utilization and performance of small reservoirs in some cases is a result of poor dam construction, lack of maintenance, or due to wrong hydrological and climatic estimations (Birner et al., 2005).

The construction of small irrigation schemes holds a great deal of rewards for communities from a cost-benefit analysis perspective, however, without proper consultation and sound engineering such interventions are often a nine-day wonder, and at best white elephant projects. The literature so far has focused on the merits of small-scale dams vis-à-vis large-scale projects whose positive effects have not been thoroughly utilized. Within this spear, there is a dearth of knowledge on newly constructed projects and the extent to which public sector funds can be justified in rolling out similar infrastructure projects in the local communities of the semi-arid regions. While the literature has pointed the way in terms of what kinds of collaborative effort are required for successful small reservoirs, there is no systematic analysis of projects such as the Vunania dam, and the Gia dug out after construction. The post-construction analysis and evaluation are as important as the pre-construction and design. Such an endeavor could help inform policy on the justification of public expenditure on irrigation infrastructure and provide a lens for assessing the sustainability of the projects against the intended aims. To properly appraise this, a look into the evolving nature of irrigation policy and projects at the local level in Ghana could provide some fertile material for further elaboration.

1.2 Evolving policies for rural agriculture in Ghana

Given the financial constraints in constructing large irrigation infrastructure, small infrastructure construction has gained prominence with some NGOs going into small reservoirs development as poverty reduction strategies for communities in Northern Ghana. With reports of their immense contribution to rural livelihood (Faulkner *et al.*, 2008; Venot *et al.*, 2012; Boateng *et al.*, 2015) there is no doubt that small-scale irrigation schemes represent an appropriate policy solution in the Ghanaian context. Though there are a reasonable number of small water infrastructures dotted around most parts of the five regions of the North, the World Bank, (2017) reported that the major cause of underdevelopment in Northern Ghana is a result of poor irrigation infrastructure, suggesting that further development of irrigation infrastructure is a sure way to develop the area. Given the dwindling investment by multinational donor agencies in reservoirs development (Williams, 2007), successive governments have put in place policies, programs, and projects to ensure water availability for its population, and one such project is the "one village one dam (lV1D)" project. In 2018, the Government of Ghana rolled out the "one village one dam (lV1D)" project which was aimed at constructing earth dams to provide water for all year-round irrigation in the five regions of the North to enhance food security in the country. Under the lV1D project, 570 small earth dams were earmarked to be constructed at an average cost of GHS 250, 000 per dam (Graphic online, 2019: Parliament of Ghana, 2019). News of the 1V1D initiative excited most people in the beneficiary areas because the people were hoping that, in addition to other uses, they would be able to engage in dry season farming with a regular supply of water from the dams. Since most of the youth travel to the south in the dry season in search of non-existing jobs having adequate irrigation facilities will afford them a source of livelihood and, engage their energies productively in the dry season and arrest the drift down south in search of non-existent jobs (Adam *et al.,* 2016). In reality, this was seen particularly as a poverty reduction strategy for communities in Northern Ghana. Unfortunately, when the dams were eventually constructed, community members were left disappointed because the dams were too small and shallow to store enough water to support dry-season gardening (Joynes, 2021). Most of the reservoirs have also been reported to dry up in the dry season, in some cases before February when water is needed most. Nonetheless, there are reports of sustainable water storage in a few dams constructed under this initiative. In essence, the available storage meets livestock and domestic water needs only.

Despite several decades of progress in efforts to improve water availability for economic development alongside evaluating the impact of these facilities (Faulkner *et al.,* 2008; Venot *et al.,* 2012), there remains a gaping hole in holistic research evaluation of newer projects. There is a growing demand for evidence-based policies and results-oriented public investment. Hence, the evaluation of projects is a central concern of policy makers in most parts of the world because, governments and Donor Agencies can appreciate the returns on their investment (Directorate for Science and Innovation, 2016).

1. Methodology

2.1 Study area

The Vunania electoral area and Gia reservoirs are located in the Upper East Region of Ghana between latitudes 10.83°N and longitude 1.059W (see Figure 1). Though contracted in the same year (2019) under the government's flagship program 1V1D, the Gia dam was under the Ministry of Special Development Initiative and awarded to a private consultant with supervision from the MDCE's office while the Vunanaia Electoral area dam was contracted under the Ministry of Food and Agriculture with supervision from the GIDA. The dam is located in the Vunania community with the irrigable area located in the Janania community. The catchment that drains into the Vunania reservoir is about 430ha. The domain is a savanna ecological zone characterized by significant temperature variations and a unimodal rainfall pattern with three seasons; Rainy season

(July to September), Dry season (February to May), and Harmattan season (November to January) (Barry, et al., 2005). The main soil types found in the area include vertisols, luvisols, lithosols, and arenosoles with annual rainfall varying from 850mm to 1,245 mm with the highest rainfall (more than 80%) experienced during the rainy season (July to September). The monthly surface temperature ranges between 27°C and 38°C with the maximum temperature experienced in the dry season while the lowest is experienced in the Harmattan season. The area is agrarian with the major source of livelihood being farming. Unfortunately, the long dry period leaves many idle and without money leading to seasonal migration while others travel to areas with reservoirs to engage in irrigation farming. With a storage capacity of $2.87x10^5m^3$ (Figure 2) and an irrigable area of 15ha, the Vunania Electoral area dam is imagined to be an economic booster for the beneficiary communities. The youth instead of being idle in the dry season will have an opportunity to earn income from dry season cropping. The Gia reservoir has a storage capacity of $2.0x10^4m^3$ in a very flat valley with the highest depth of 3m but the overall average depth is about 1.5m. Figure 1 presents the focus group locations at the study area as well as the Vunania Dam Boundary.

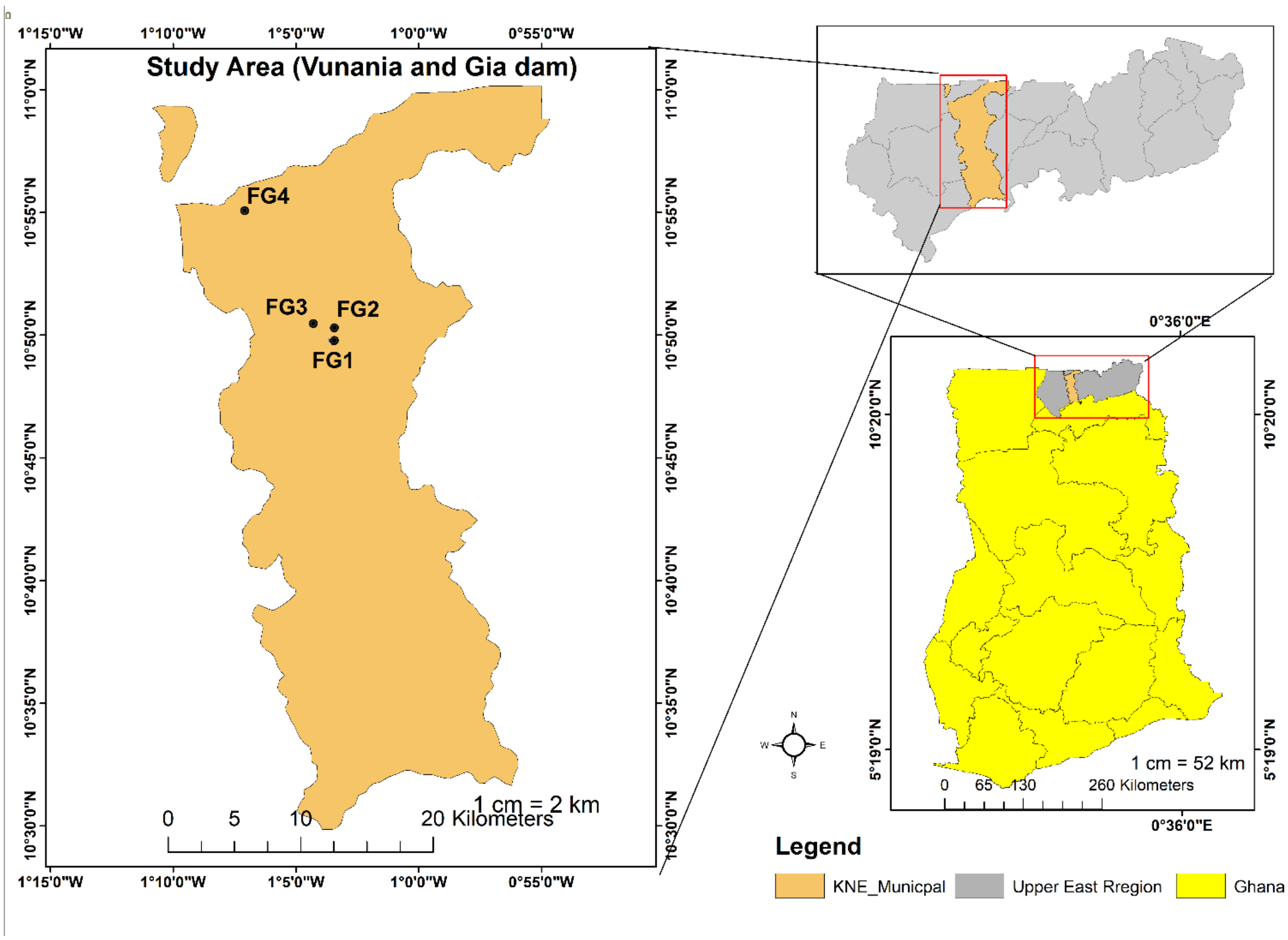


Figure 0.1 Location of study Area (Vunania and Gia Dam)

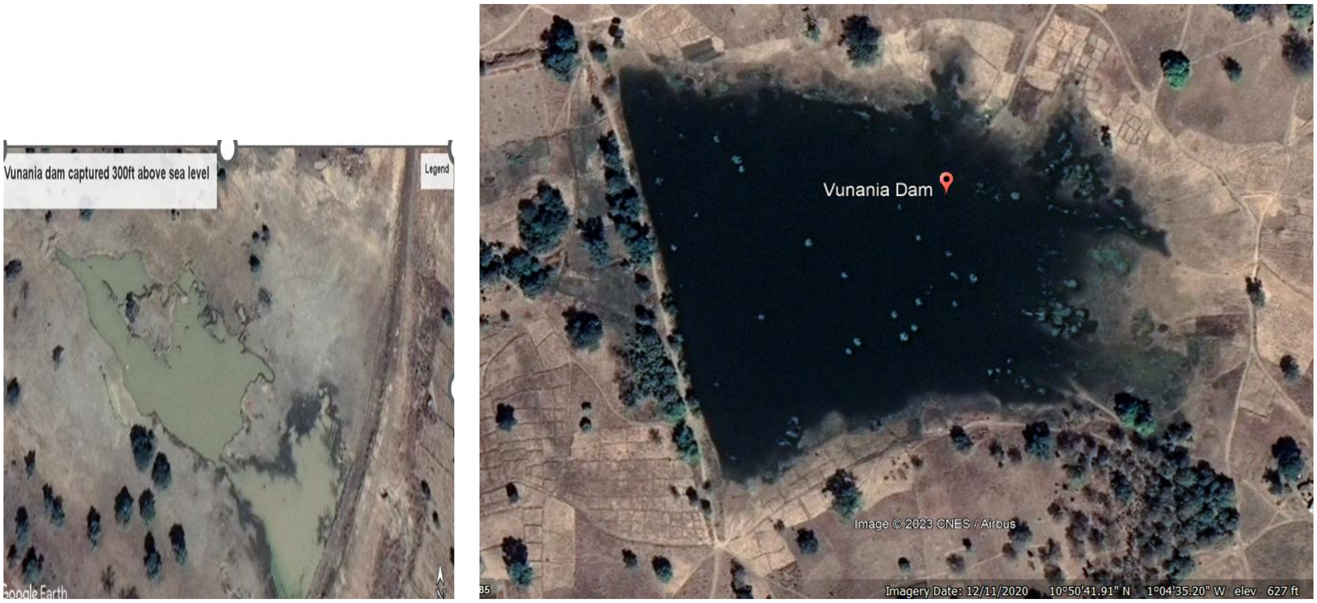


Figure 0.2 Google earth image of the Vunania first and second years after impoundment respectively.

2.2 Data collection

The research employed a qualitative approach consisting of focus group discussions, experts' interviews and key informant interviews. We undertook field visits to the dam sites to observe and assess the various components of the dam**.**

2.2.1 Field observation and dam component analysis

Field observation is a qualitative research method that helps to gain an insider view of the setting. The Vunania dam site and Gia dam were visited, and observations were made on key components of the reservoirs while point elevations were taken to aid analysis. The following aspects of the dams were examined; activities around the reservoir, the dam wall structure, the spillway, and the irrigable area. Interaction with experts from GIDA and MoFa was undertaken to verify certain conclusions from field observation and to understand the state of the dams from their perspective.

2.2.2. Participant Recruitment and Qualitative data collection

The Vunania reservoir is a newly constructed dam that only impounded water two years ago. With the irrigable area still under construction, a few farmers cultivated at the upstream end using pumping machines and holes. The focal discussions were held in three groups in the Vunania area; The first group consisted of farmers at the dam site, and the second group were the opinion leaders including the Chief, Landlord, Assembly man, the Youth leader, and two Elders. The last group included the women group using water for raising tree seedlings downstream. The selected study areas had water storage systems constructed at the same time. Both areas are predominantly agricultural with some women groups raising seedlings for afforestation projects. Accordingly, the authors consider the selected study areas very significant as the beneficiary communities consider this water infrastructure as a game changer for their economic turnaround. The key informant's interview was conducted with people who have a stake in the dam construction process and its utilization. Focus group participants aged ≥18 years. The following information was relayed to participants before recruitment, Participant requirements, Data use, Date, location, time of the focus group meeting, and benefits of study participation.

In all, four focus group sessions (FG1, FG2, FG3, and FG4) were successfully completed with 33 participants, facilitated between December 2022 and January 2023. Thus, three in Vunanai and one in Gia. Good practice techniques were followed during the recruitment and reminder stages ((Sim Julius, 1998). All sessions met the minimum number of participants typically required to be considered successful i.e., four participants (Sim, 1998); Krueger, 2000). The focus group was successfully completed as the achievement of a group dynamic enabled collation of different perspectives from attending participants. In line with the approach of McLafferty (Isabella, 2004), the moderator began the sessions by discussing basic ground rules, while participants were assured that the research team was seeking to learn from the participants (Sim, 1998) and were encouraged to share their views and experiences without repercussion or judgment. Participants were also reminded that upon their verbal consent, sessions would be recorded for analysis.

The moderators sought verification and validation from participants during the focus group sessions. Techniques adopted for verification and validation included, for example, repeating viewpoints back to the participant group to see if the view was shared by all members of the group, which has been shown to help ensure research precision and interpretive validity (Morse *et al.*, 2002). Focus groups were steered by a topic guide, subtopics, follow-up questions, and probes. During discussions, the moderators applied what Namath and Shuler, (1990) refer to as 'mild, unobtrusive control' to avoid group domination and facilitate a group dynamic.

Prior to focal discussions, focus group members completed a short survey developed specifically for individual participants (Appendix A,) comprising ten multiple-choice questions. Questions examined the ages of participants and all household members, gender, farm ownership, and the number of years of farming in the location. Participants were also asked to state where they derived their livelihood before the construction of the reservoirs. Finally, questions on the range of income they receive from engaging in irrigation farming were asked. To avoid order-effect bias (Hale *et al.*, 2007), both survey questions and available responses were presented in random orders where possible. In recognition of their contribution to the study, each participant was offered an allowance for participation.

Table 1: Focus group location and participant characteristics

Focus Group	Date	Location	n(Male/Female)	Farmland Ownership
FG1	20/11/2022	Vunania dam site	11/2	11
FG2	5 /1/2023	Vunania chief palace	6/0	3
FG3	7 /1/2023	Vunania township	1/8	4
FG4	12 /1/2023	Gia dam site	3/2	0

2.2. Data Analysis

Initial screening of the focus group audio recordings and raw text transcriptions was performed to identify broad themes common across focus groups (Nicholls, 2017). Secondly, the responses were organized using the questions applied during data collection. A form of naive categorization of broad themes (e.g., "perceived and tangible benefits of reservoirs" and " Sustainability of the reservoir"), was applied, signifying the first coding interpretations of the researcher. Then, the recordings and text were reviewed more closely, and more detailed coding was used in line with the thematic descriptors, elaborated in Table 2. Next, the coding was reviewed by a third party for validation. Finally, obvious patterns emerging in the focus groups were detected from basic categorizations which were refined, organized, and interpreted based on the specific objectives of the study.

Table 2: Themes and thematic descriptors

Themes	Thematic Descriptor
General thought on reservoirs	Participants' perception of reservoir infrastructure and their level of satisfaction with the facility
Perceived benefits and barriers	The benefits that participants perceived from the siting of the reservoir in the community and barriers that will likely hinder the full realization of these benefits
Sustainability of reservoir and dealing with perceived threats	Participants perceived thoughts on how sustainable the reservoirs are and how to deal with factors likely to threaten their sustainability
Perceived Community's role to ensure reservoir sustainability	Participants' contribution towards the sustainability of the reservoir

2. Results and Discussion

The study employed site visiting; focus group discussion, expert interviews, and informal interviews to find out how the implementation of two categories of dams, (a dam constructed under a world band funding through GIDA and a dam constructed under the 1V1D policy) is serving the beneficiary communities. Through our site visits and observation, various aspects of the dams were assessed and presented in this section. By interacting with community members, we were able to understand the state of the dam from the community members' perspectives their expectations, experience, frustrations, and satisfaction regarding the dams constructed for their benefit.

3.1 The Vunania Electoral area dam

3.1.1 History of the Vunania Electoral area dam

The Agric department was already running a cooperative farming project in the Vunania valley around the 1950s. At the onset of the rainy season, they would plough the fields and share them among women from within the entire catchment area (Janania, Ghane and Bundunia, and Vunania). The women constituted a group called the "Makazia" group. Because of the level of success of this intervention, the department realized that if they could build a dam there, they could project the initiative into the dry season so that people can farm in the dry season. Between 1960 and 1965, the Land Planning and Soil Conservation Unit of the Ministry of Agriculture came and conducted a feasibility study, spotted a suitable point in the valley and pillars were planted to construct a dam to encourage small-scale farming. Unfortunately, after the coup in February 1966, the whole process stalled. The community members had lost hope of this great intervention but about 50 years later in 2019, GIDA obtained World Bank funding to undertake the construction.

Regrettably, the dam is not constructed at the point where it was initially earmarked to be constructed. This can be attributed to the failure of implementing institutions to visit their archives to source information from the earlier engineering surveys as well as their inability to take the views of the indigenous people. Hence, the community members believe that the project was rushed through. One of the elders in the community had this to say.

"We have lived here all our lives and we have the knowledge of the water ways, and the local geology of the area but when we made our submissions, they did not utilize it fully. Apart from the indigenous knowledge of the community members, 50 years ago, excellent sound engineering surveys were conducted all over the country spotting suitable sites for reservoirs. If they had consulted their archives for the past location and design without even listening to our views, I believe the project would have still been executed to our satisfaction. This is because the location we insisted the dam be sited is the same location the pillars were planted by the first engineering survey in 1963 and signs of the pillars are still there. It should be noted that what the technocrats have to investigate to find out about our environment we already have knowledge about it because it is our environment".

The chief also mentioned that,

"I explained to them that there are already poles planted in the earmarked site so they should site the dam there, but they only moved downwards a bit from the school and started work."

The current location of the reservoir only impounds water from one valley as against the initially marked location that would have impounded water from three valleys, because it is located behind the confluence of three valleys. This would have implied more storage for significant and sustainable dry-season farming with an irrigable areas extending to Golgo and Naaga. Though the community members feel that the selected site is inappropriate, they are happy about the project.

The Chief Engineer at the District Assembly confirmed this but with a bit of difference regarding the dam wall sitting.

"In the early 1960s, the Vunania valley was already an organized rice field serving as a training center for some farmers within the region. The archeological evidence of platforms constructed at vantage points for the threshing and drying of rice are there to show. The site was later earmarked for the construction of a reservoir to extend farming into the dry season for which reason initial surveys were conducted and pillars planted. However, the pillars were not planted to indicate the geographical location of the dam wall, but rather the buffer zone of the catchment within which the dam should be located. So it is the available fund that termines the storage capacity and for that mater, the location of the dam wall"

According to one of the field engineers of GIDA,

"The proposal has been there for several years after the initial surveys but because there was no funding, the project stalled. Depending on the source and available funds, it may require a redesign of the dam in order to construct a standard dam to suit the available fund. This was the case with the Vunanaia electoral

*area dam when the funding was finally sourced. T*hough *Information from our archives was used, the design had to change to suit the available funding and the design volumes eventually informed the citing of the dam wall".*

Generally, the views of the community members were in contrast with that of the technocrats. Several factors determined the design and positioning of the dam which the community members may not be preview to. To the community members, the pillars were planted to indicate the embankment benchmark or location of the dam wall whereas in reality, they are just to indicate the catchment area within which the dam should be constructed. Therefore, it is as a result of ignorance that the community members feel that the dam wall was to be located where the downstream pillars were planted. These misconceptions could have been settled with proper community engagement and sensitization.

3.1.2 Characteristics and state of the Vunania Electoral area dam

The Vunania dam is an impoundment fed with water from a 430ha catchment area, a full-scale storage area of 11ha, a maximum depth of 7m, *an* embankment length of 470m, storage capacity of $2.87 \times 10^5 m^3$ and a concrete channel spillway connected to one end of the embankment. The inner face of the embankment is covered with boulders to prevent crocodiles and other reptiles from boring into the embankment. Restricted areas are created in the catchment area by planting Vetiver grasses at the periphery of the dam to trap sediments and trees are being raised to be planted within the buffer zone to prevent farming within the buffers to check reservoir siltation. Impoundments with catchment areas ranging from 10-544ha; storage volumes ranging from $0.15 \times 10^6 m^3$ to $0.47 \times l0^6 m^3$, the full-scale surface area of 3.5-28ha, a maximum depth of 2.0-6.5m and embankment length of 100-1,000m are classified as small reservoirs (GIDA, 1995). Hence, the Vunania dam falls within the range of small reservoirs.

The dam was designed to have a developed irrigable field of 15ha downstream of the impoundment. Water abstraction to the irrigation field is by means of a water outlet point connected to an inlet chamber via a conduit pipe located in the middle of the impoundment. The outlet point located behind the embankment is connected to a distribution point (furnished with control valves). Water from the distribution point is also designed to be transported to the irrigation fields by gravity via closed pipes. The pipe system is chosen over the open canals because it is efficient and has fewer losses to evaporation and seepage. At present, the irrigation facility is still under construction and so, a few farmers engage in gardening at the upstream end of the reservoir. Irrigators rely on motorized pumps, buckets and watering can technologies to transport and apply water in their crop fields which is tedious and expensive. For this reason, the plot sizes of farmers are much smaller, ranging from 0.01ha to 0.05ha, and a total irrigated land area of about 1.5ha. All farmers engaged in vegetable farming including, tomatoes, pepper, and leafy vegetables. With the completion of the development of the irrigable area, where water is diverted from the canal to flow by gravity down the furrow between rows of crops, farmers are hopeful to increase their farm sizes significantly, since they will be able to water a substantial area over a short period at a lower or no cost.

3.1.3 Benefits of the Vunania Electoral area dam

Although the Vunania dam only started impounding water three years ago, participants in each focus group expresses joy since the dam has proven to have great positive significance. During an impact assessment, participants of the focus groups highlighted numerous benefits derived from the dam. The impact of the dam was categorized into; economic, social, and environmental.

Notably, participants who live a few meters away from the reservoir expressed the environmental benefits of the dam regarding the cooling effect of the water body. Some of them put it this way:

FG1 "*Previously before the dam was constructed, during the month of March the heat was so unbearable but now the heat has reduced. That is why we attribute the relatively lower temperatures in the month of March to the cooling effect of the water in the reservoir currently present".*

FG2 "Due to the area's distance from the water source, initially only a few people built around here to stay but now with closeness to water and the fact that the area is cooler in the hot season because of the dam, more people have started building their houses around here".

The construction of the reservoir has resulted in an increase in profitability from the rearing of livestock and others have introduced the rearing of pigs all of which will increase their income. Participants that have experienced a reduction in losses of their livestock tended to associate it with the presence of the water body in the community since livestock do not have to go far in search of water:

FG1 "Since the reservoir impounded water, I have not encountered any loss of my livestock because they are always around the reservoir grazing and when they are thirsty, they don't need to go far"

FG3 "Our livestock don't get lost again and at the same time my husband has started rearing pigs in addition to the livestock and we are able to conveniently pay our kids' fees as the pigs proliferate more and faster".

Though some farmers used to engage in dry season farming at the Tono irrigation site, they have moved to farm at the Vunanai dam site, which has made it easier for them to effectively engage in multiple livelihood activities due to the dams' proximity to their homes (Plate 1). Also, all focus groups cited the tendency to improve their standard of living since they can do irrigation farming on larger farm plots. Furthermore, the presence of the dam creates employment for the youth and hence reduces seasonal migration. For instance:

FG1 "I used to farm at the Tono irrigation site and so because of the distance I go early in the morning and return late in the evening but now, with my small farm here I can go back home to check on my livestock, guinea fowl eggs, pick up my kids from school or even go and harvest my honey from the bee hive and still come back to the farm. Hence the nearness of the garden to my home makes it easier for me to execute multiple tasks within the day".

FG1 "In the Tono irrigation site where I used to farm, I did not have access to a large farm plot which has always been my desire, but since this reservoir is located in our community and on our land, I am hopeful to have a larger farm plot which will translate into an increased income for me and improved economic condition of the Vunania community".

FG2 "The presence of the Tono reservoir in Navrongo has enriched many people in Navrongo and surrounding villages, the same way we believe that the Vunania dam will enrich our people and bring development as many more people build block houses".

FG3 "The unimodal rainfall pattern limits us to one season of cultivation (June to October) in the year and throughout the dry season we have nothing to do except those who are able to obtain a plot at the Tono irrigation site to farm. Because of that, our sons are compelled to travel to the southern part of the country in search of jobs in the dry season because they are idle and without a source of livelihood. However, with the availability of water, they can engage in all-year farming and our children will not travel to the south in the dry season again".

These views are confirmed by Adam et al., (2016) and Akudugu et al., (2016) that, out-migration of youth and the percentage of poor people was much lower in areas with irrigation infrastructure as compared to communities without.

Plate 1 Irrigation farming at the upstream area of the Vunanai dam with some farms sited too close to the reservoir

Unfortunately, some of the farms were sited too close to the reservoir (Plate1-left) and that can result in rapid sedimentation of the reservoir, leading to a further decrease in reservoir storage (Atulley *et al.*, 2022). Hence, the reservoir buffer should be grassed, and farming prohibited within the boundary to curtail sedimentation.

Other uses of the Vunania reservoir mentioned by some group members across all the groups include fishing, domestic purposes, and construction. The nature of the reservoir with trees submerged in the reservoir makes it a site to be seen so it serves as a tourist site sought of. Some people draw the raw water with motto-kings and sell it in drums.

FG1" We used to buy raw water in drums for constructional purposes but now we rather sell water to people in other communities and it's a good source of income".

3.1.4 Perceived threats and sustainability of the Vunania dam

The expectations of the Vunanai community members on the dam are enormous. Meanwhile, some expressed mixed hope due to the incompletion of the irrigation area as well as some challenges with the dam. During the focus group discussions, key informants' interview sessions, and field observation, some key challenges were identified that may likely limit the people's realization of the full benefit of the dam.

3.1.4.1. Water Oozing of the ground behind the dam wall

Water was observed coming out from the ground at both ends behind the dam wall. The water was so much that it could be seen virtually running gently on the surface (Plate 2). Hence, the ground is wet even up to a mile away from the location. The community members are particularly worried about this situation because it means much of the water will be lost which could have been put to profitable use. The community members attribute it to seepage from beneath the toe of the embankment, which is a result of inadequate compaction of the foundation layers. The Assembly man stated that;

"The reason why we are of a strong view that the water is seeping from the dam through the toe of the enbankmenr is that, at the time of construction we the community members came around daily to help and we observed that, anytime the GIDA Engineer is around he insisted that they sprinkle enough water on each layer before ramming to ensure proper compaction. The contractors mostly comply but immediately the engineer is not around they don't sprinkle enough water before compaction" because of that the foundation layers are not properly compacted, particularly at the ends of the embankment, making it easy for the water to seep".

An elder in the community also stated that;

"The challenges of the dam shortly after construction especially the water coming out from the ground behind the dam wall is making us very worried. The reason why I believe it is a result of seepage from the dam is that, before this dam was constructed, that area was always dry after November but here we are in January and water is still coming out from the ground. Apart from the wasteful loss of the water, it may even threaten the safety of the dam if not corrected".

These fears are realistic given the fact that good compaction of layers ensures the stability and sustainability of earth dams (Özer and Bromwell, 2012).

Some community members also hold a milder view that burrowing of holes underground by reptiles such as crocodiles may create room for the water to go out, hence the need to scoop the area where the water is coming out and trace the sauce of the passage.

The key areas to be concerned about and ensure critical supervision are the toe formation (ensure the right material is used, thus material high in clay) and the valve area (which should be well treated with the right material). In placing the conduit pipe, an impermeable diaphragms is usually casted with very rich concrete around the conduit in intervals of about 3m along the pipe. These are known as anti-seepage collars and they prevent flow along the interface between the conduit and the compacted backfill. Also, it increases the length of the flow path for seepage water and by forcing water to flow a greater distance, more hydraulic head is dissipated. According to the Kasena Nankane Municipal Chief Engineer, Critical attention was not paid to these susceptible areas for seepage during construction. At the same time, certain actions of community members could have resulted in the perceived seepage. He recounted that,

"After the installation of the valve, they realized it was not rightly positioned so it was removed and repositioned. Therefore the repositioning of the valve again may have broken the seal of the toe which the contractor probably overlooked. Hence, the water at the mid portion may be coming out along the pipe of the valve. There may also be another water layer somewhere that is feeding the sources".

He also added that the problem is partly attributed to the reengineering and modification done by the contractor besides the data that were given in order to satisfy the demands of the community members.

"When the contractor moved to the site, the community members especially the youth were always critical while pushing their views through. Therefore, the contractor at some points had to alter certain parts of the project to suit the interest of the community. One critical thing the contractor did on community demand was the extension of the dam wall length and increasing the height of the spillway to store more water. Hence, the adjoining point of the extension works may likely be the point of water loss to the downstream end since the adjoining part was constructed after the main dam wall was almost completed".

According to the GIDA field engineers, inadequate compaction of the dam wall layers cannot be ruled out as a possible cause of the water oozing out of the ground but also added, they strongly suspect two main causes of the challenge:

#1. Activation of dormant springs because of the pressure from the impounded water or

#2. Pore spaces in the geological formation underneath the impounded area, pure clay or pourouse material lining in the impounded area.

One of the Engineers stated that,

"The reason why my first suspicion is the porosity of underlying geological formations but not seepage through the dam wall is that; there are heaps of gravel at both upstream ends of the embankment area, which is an indication of the possibility of porous rock formation beneath the seeping location. Hence, the porous nature of such rocks allows water to percolate, and then by virtue of the pressure of the impounded water, water is forced out from the ground at the back of the embankment through the pore spaces. Furthermore, seepage flow is usually turbid because the seepage force erodes fine soil/clay particles from the dam wall materials and washes them out resulting in the turbidity of the water. Meanwhile, the water coming out of the ground is clean and clear, indicating that it is not seepage flow. Additionally, the water is coming out from the ground 6 meters away from the dam wall, and examining the toe of the embankment, there are no signs of wetness at the back of the dam wall. All the same, the source of the defect needs to be identified and corrected".

It is important to note that almost all reservoir have some seepage. This is because the water in the reservoir usually seeks paths of least resistance through the dam body and foundation and when there are pore spaces beneath the impounded area water will find its way out through these pores. The good thing about the Vunania dam is that there is a fine clay lining at the mid-reservoir portion. Also, assuming the water is a result of pore spaces in rocks underground, as the water percolate and escapes to the backside of the embankment, the pores will be blogged gradually with particles in percolating water as they settle and with time the water loss will reduce (see Pham *et al.*, 2013). Moreover, the water coming from the ground at the back of the embank is within the irrigable area so farmers with such plots will need very little or no watering for their crops, and at the end of the day, it serves the same purpose.

Plate 2. Water oozing out of the ground a distance away from behind the Vunanaia dam

Though all stakeholders have different views regarding the cause of the problem, they all agree that the source of the defect needs to be identified and corrected. Ascertaining the source of the defect is the first step to solving the problem. Hence, the case must be investigated carefully, and application of the necessary remedies should be done early to prevent it from becoming serious. The folowing are recomended to unravel the cause of the problem;

- Begin with a thorough examination of the dam wall to look out for wet points, in case its seepage from the dam wall
- Trace to the source of the water oozing out of the ground by digging a 4x4m trench with 2m deep at the point of water loss and observe the direction of flow. This can be done with ordinary tools like pick axe and shovel.
- Drain dam and observe if there are cracks in the impounded area. If the area is covered with pure clay, the cracks will result in seepage. Also if its covered with pervious material such as sand, there is bound to be seepage. If it is purely clay then it should be mixed with small amount of other material and if it's sandy, a lining high in clay should be introduced.
- Conduct geotechnical diagnosis of the dam wall to ascertain if the compaction was well done. In-situ investigation is recommended but not the destructive geotectnical analysis as done on layer by layer during the construction phase.

One major difficulty in seepage analysis is finding the position of the phreatic surface which is unknown, but when determined in an iterative process starting with an initial guess for the unknown seepage boundary, it is possible to find a solution to it (Mohammad and Farhang, 2011). This is recommended to ensure that rightful measures are taken to prevent it from developing and adversely affecting the safety of the dam (Pham *et al.*, 2013).

3.1.4.2. Discrepances with embankment and spillway

The embankment is slightly low and at the same time, the spillway is a bit high (Plate 3) so during the peak of the rains the water fills up close to the crest of the dam wall. Participants of the focus groups indicated that, during the last rain, the water filled up reaching almost the crest of the embankment, which they feel years of excess rain will result in the water overflowing its banks and that might threaten the sustainability of the dam. The field observation also revealed that the spillway end of the impounded area has a higher elevation (247m) (Plate 3) than the other end, with a lower elevation of 228m above sea level. Implying that the water will have to rise a bit further before it spills at the high elevation end. Hence, increasing the embankment height will reduce the possibility of water overflowing its banks in very wet years. Moreover, there is a heap of gravel at the left bank of the impounded area towards the spillway, which probably blocks the water from flowing out. Hence leveling this heap will allow water to flow out easily through the spillway when water rises up to the full supply level. Additionally, the valley is not very deep resulting in a shallow reservoir except for portions close to the dam wall making the reservoir vulnerable to evaporation. Hence, the beneficiaries believe that it is necessary to remove part of the earth to create room for more water to be collected from flash floods in the rainy season and reduce evaporation. One of the elders of the community said;

"*In the second year, the dam impounded water so much to the extent that it nearly spilled over the main embankment, so the engineers quickly came and brook down the spillway for the water to go out. It has since been reworked on, but it is still high. Really if this project will meet its intended purpose sustainably, it needs to be thoroughly assessed and reworked on".*

Regarding the Embankment height, the GIDA engineers are of a different opinion. One stated that, *"The surface of the embankment is not uniformly leveled hence the contractors have to work on leveling the surface but regarding the embankment height, it is gone beyond the design height hence okay".*

Plate 3. Spillway of the Vunanai dam and the high elevation of the impounded area leading to the spill

The embankment's undulating surface was noted, and it was found that downstream 1 in 2 was not fully applied during the dam wall process (plate 4). The residents of the community have indicated that the undulating surface is caused by car ties sinking after they have passed on the embankment. This is what a community member said.

“The effect of the unduclation you are seeing on the enbankment is that when the second contractor arrived to work on the irrigable area, his tipper truck carrying sand passed on the enbankment and its ties sank a little”.

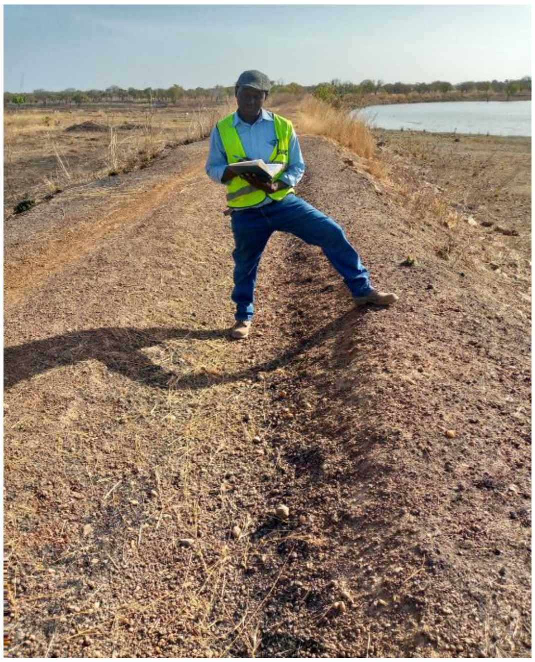
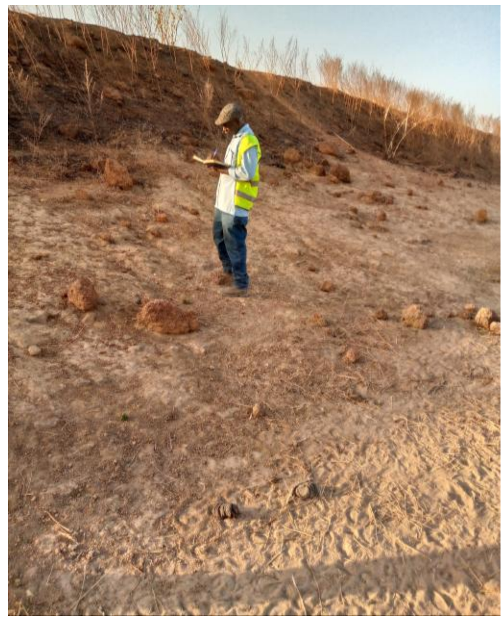


Plate 4. Undulating enbankment



Downstream 1 in 2 not fully applied on enbankment

3.1.4.3. Discrepancies in the irrigable area development

Shortly after the irrigable area was developed, some anomalies were also noticed there: i) Portions of the canal are broken and not entirely straight in some places (See Plate 5a); ii) nine leaks were found between the seven laterals along the main pipe line. iii) The offtake and lateral chambers appeared to have malfunctioning valves.

For this reason, community members are concerned and fear that the irrigation facility may likely be faced with challenges just like the dam infrastructure and insist that GIDA engineers step-up supervision to ensure value for money so that when completed the community members can reap the full benefit of the investment. Although the project was perceived as the vehicle for the community’s economic state to be improved, the chiefs and community members expressed mixed reactions because of the myriad of challenges they see emanating from the construction works. They, therefore, appeal to the Government to step in so that the great potential savior of the Vunania and surrounding communities do not become a “white elephant”.

Plate 5. Breakages already at some portions of canals.

Plate 5b -leakages in the irrigable area along the main pipeline

Plate. 6. Faulty Valve at the Offtake Chamber (left) and Lateral Chamber (right)

Even though the community members are excited about this project. Their hope is blurred by the challenges of the dam shortly after its construction. Given a total contract sum of over Ghc200, 000, they believe that the output should have been better than what they are given. This is how the Assemblyman put it;
"For the current state of the dam, I believe that the project was not executed to its best and hence the investment is not justified".

On the other hand, the Engineers from GIDA and the Municipal Assembly believe that some of the lapses observed after the construction are partly a result of the actions and inactions of community members particularly the youth in the sense that; They were always around and insisting on certain actions which are sometimes not in line with the designs. "*In essence, the community youth were more of supervisors to the contractor and ended up reengineering the reservoir".*

As to whether the investment is Justified or not the Chief Engineer had this to say.
"The contract sum is not the take-home of the contractor but the completion certificate is what the contractor uses at every stage to make claims. At every stage, the contractor presents certificates and the project managers go to crosscheck every item before the fund is reimbursed to the contractor. At the end of the project, if the volume of work does not exhaust the contract sum, the balance remains in the project fund. As of now, the fund is not exhausted and since I have not analyzed the volume of works against the amount reimbursed to the contractor, I cannot categorically state if the investment is justified or otherwise".

Regarding the sustainability of the dam, the community members believe that it can only be sustainable if these 3 main challenges are addressed;
#Toping up of the embankment;
#Correcting the perceived leakage problem
#Scooping out the soil in the impounded area to create more room for storage. They also added that they are poised to play their role towards the sustainability of the dam including planting grasses around the reservoir and strictly enforcing the buffer boundary restriction to prevent siltation. The community members also indicated that with some technical guidance from GIDA personnel, they are willing to offer their labour, resources such as motor kings and financial contributions towards the finishing of the reservoir and irrigation infrastructure.

3.2 The Gia reservoir constructed under 1V1D

3.2.1 Characteristics, impact, and sustainability of the Gia reservoir

The Gia dam was constructed in 2019 under the one village one dam initiative aimed at improving rural livelihood and food security. The reservoir is an excavation positioned within a flood plain and constructed by scooping the sand in the flood plain/depression beside a road using bulldozers

and excavators to create the embankments (Plate 5). The impoundment has an embankment length of about 55m, a maximum depth of 3m, a full-scale level reservoir of 1.2ha, and a storage capacity of $2.0x10^4 m^3$ in a flat valley. The embankment is not constructed with boulders like the embankments of small reservoirs and it has no spillway with the quality of the embankment not up to standard. In short, the structure is not engineered. According to Ofosu, (2012), impoundments with embankment lengths ranging from 30m to 314m, maximum depths ranging from 0.7-3.0m, full-scale level reservoir area from 0.04-3.2ha, and storage volume of $4x10^3 m^3$ to $64x10^3 m^3$ are categorized as dugouts. Additionally, dugouts typically lack engineered embankments. Hence, the Gia dam can fit into this category. Due to its small storage capacity, it cannot be used for any dry-season farming. In fact, as early as January 2023 when the research team visited the site the water had dried up with just a pocket of water at the deepest portion close to the dam wall. The Peasant Farmers Association of Ghana (PFAG), on the Gia reservoir as well as others constructed under the 1V1D project, made a similar observation (PFAG, 2020). Nonetheless, the impoundment supplies water for livestock watering in the dry season. Just like most dugouts, the Gia reservoir lacks intake structures in the impoundment and lacks officially developed irrigable areas. While other dugouts have reasonable, storage, and farmers develop their fields around the upstream sections of the reservoir, resorting to motorized pumps and hoses to transport water to irrigation areas, the Gia dugout can barely store enough water to last to the end of the dry season for livestock watering. Hence, it's not serving its intended purpose (see PFAG, 2020; Graphic online, 2022).
Community members indicated that they were only informed of the project but were not involved in its execution. Meanwhile according to Seleshi *et al.,* (2009), for water harvesting structures including small reservoirs to be successful, the communities must participate in the planning and construction of the structures and accept responsibility for their operation and management. Some community members were of the view that if they were involved from the planning face and knew the nature of the project, they would have proposed aggregating a number of dugouts to construct one reasonable dam at a suitable location. This view is highly realistic because, for projects with the goal to improve water availability for livestock and irrigation farming, Lasage and Verburg, (2015) stated that the analysis of 85 articles and reports provides evidence that it is better to aggregate the money allocated for dugout to construct large schemes. They added that in case of limited funds, it is better to go for subsurface dams and sand dams that make water available at USD 0.04 and USD 0.40per m^3 on average compared to smaller reservoir systems that make water available at USD $1/m^3$ to USD $9/m^3$. Involving technocrats in the project design through to the implementation phase would have prevented the discrepancies in the project output.

Some of the community members had this to say;

FG4 "if they had put together the money they used for the Kajolo, Gia, and Nimbasinia dugouts to construct one reasonable storage system in a suitable location it would have been better off".

FG4 "the news of the intervention heightened our expectations but when the project was finally delivered, we became sad because our expectations were not met".

The Municipal and GIDA engineers also had this to say about the Gia Dam,
"The location of the dam is not suitable and the topography of the area is too flat for dam siting. They did not form any foundation to hold the wall (Key trench), they just heaped earth material on the bare ground to form a normal hill which they refer to as the dam wall. After constructing it, the water dried up immediately after the rains ceased. So the contractor went back and dug a steep pit towards the wall of the embankment to create room for more water. Because the pit does not have a gentle slope, when animals try to drink from it they easily get trapped".

The engineers in the assembly and GIDA were not involved particularly in the implementation stage, hence the project execution lacked that touch of professionalism. The lapses we see in the project are therefore not surprising. These findings are similar to the observations made by GIMPA and PFAG research teams who reported that most reservoirs constructed under the Government's flagship program 1V1D are not serving the intended purpose due to poor siting and noninvolvement of key stakeholders including the local communities, the District Assembly and GIDA in the conception and implementation of the project (PFAG, 2020; Graphic online, 2022).

Plate 4: The Gia reservoir constructed in 2019 under the 1V1D showing a flat valley with a pocket of water in the deepest part.

According to the Engineers, it is possible to revive the Gia dugout
"*To improve it, the idle thing is to just reopen it, completely scoop a key trench, and bring in burrowed material to form an inner seal base with clay so that it does not self-drain. It should be scooped and create a gentle slope towards the dam wall"*

With small-capacity dugouts such as the Gia reservoir, it is possible to have used community labour with some form of financial motivation. For instance, the Brigade reservoir in Vunania (Plate 6) was engineered locally with community labour and minimum financial motivation from an NGO (food for labour approach) in 1963. The dam was meant for livestock watering, tree plantation establishment, and domestic water supply. Apparently, the water is serving its intended purpose sustainably in addition to minimal irrigation farming in the dry season up to date.
Unfortunately, sedimentation has resulted in reducing the storage capacity hence now restricted to

only livestock watering, commercial raw water sale, and domestic purposes. The limited funds could have adopted this approach as it is currently used by the Ghana Social Opportunity Project (GSOP) and now the safety net project with supervision from GIDA for construction and maintenance of small earth dams with accompanying irrigation facilities (Local Government, 2021). The Safety net project that evolved from the GSOP project is a Labour Intensive Public Works (LIPW) approach, created under the local government with supervision from sector institutions including GIDA to expand employment and cash-earning opportunities for the rural poor during the agricultural off-seasons (The World Bank, 2020). The GSOP and safety net approach directly involve community individuals using handheld tools such as pick axes, hoes, and shovels with heavy machines used on tasks that human labour cannot execute. At least 50% of the construction cost goes into payment of community labour, which serves as a livelihood support system for them while they still contribute to creating an asset for the community (Devereux, 2002).

Plate 5. The Brigade reservoir in Vunania constructed using community labour in 1963, still sustainably serving its purpose.

The investment cost for small-scale irrigation reservoirs in Semi-arid Regions was evaluated at USD 2000-5000/ ha of surface area with inland valley bottom and soil and water conservation areas costing a bit less (1000/ha) (NEPAD 2003, Lanford 2005, Inocecio et al., 2007; Lasage and Verburg, 2015). The amount allocated for the construction of each dam under the 1V1D was GHC 250,000. At the time most dams were constructed (2019-20), the exchange rate was about 11 cedis per dollar implying that each reservoir was allocated USD 23,000. Assuming that inflation results in an increase in cost and the higher bound doubles, that would mean about USD 10,000/ha. Bearing in mind that the surface area of the Gia dugout is just about 1.2 ha, it is possible to have constructed a reasonable dugout that could supply water for minimal irrigation in the dry season and livestock. Although PFAG (2020) and GIMPA (2021) indicated that the allocated amount is woefully inadequate, it is obvious that the contract sum could have executed a better and more useful small reservoir if technical inputs were taken seriously, and community involvement optimized. The shoddy nature of the project output may largely be because of corruption, the number one enemy of quality project execution in Africa (Hasty, 2005; Venot et al., 2011; Brierley, 2017). Although USD 23,000 is allocated to the project, government officials and party people seeking percentages will deplete the project fund considerably, and by the time the money gets to the contractor, about half of the total contract sum is gone and the contractor will have to manage with the remainder to do "something to represent the allocated project". Hence though the allotted fund for the project is not smaller than the investment cost of small-scale reservoirs in semi-arid Africa (Lasage and Verburg, 2015), other factors such as corruption and lack of technical know-how would have contributed more to the abysmal output of the Gia reservoir as well as the other projects under the 1V1D.

4. Conclusion and Recommendations Conclusion

4.1 Conclusion

This study assessed the state, impact, and sustainability of two reservoirs. Though contracted in the same year (2019) under the government flagship program 1V1D, the Gia dam was under the Ministry of Special Development Initiative and contract awarded to a private consultant with supervision from the MDCE's office while the Vunanaia Electoral area dam was contracted under the Ministry of Food and Agriculture with supervision from GIDA.

The study found out that from the 1950s to the early 1960s, the location of the Vunania dam was already used for cooperative farming between the Agriculture department and a women's group in Vunania and surrounding communities. With the intention to extend this initiative, the area was earmarked for a dam. Haven conducted the engineering surveys, the process to source funds for the construction of the dam commenced and the coup in 1966 interrupted the project until 2019. The beneficiary communities (Vunania, Bundunia, Ghani, and Janania) applauded the government for making their dream of farming all year round come true. The facility is 85% complete and community members hav started reaping benefits from it through irrigation, livestock watering and fishing. Although they see the dam as a vehicle for poverty reduction and wealth creation, they expressed displeasure at few lapses realized after the construction;

1. ***Perceived seepage ;*** All dams have some seepage as impounded water seeks paths of least resistance through the dam and its foundation. However, it becomes a concern if it is excessive and carry material with it. In the case of the Vunania dam, the water loss is massive and more likely attributable to seepage due to a poor key trench (Poor compaction, poor material (not enough clay), Or key trench not deep enough). Although all stakeholders do not agree that the water loss is a result of seepage, they all agree that the problem needs to be solved. Ascertaining the source of the defect is the first step to solving the problem. Hence, the case must be investigated carefully, and application of the necessary remedies should be done early to prevent it from becoming serious.
2. ***The embankment and spillway***; There is the belief that the embankment and spillway still

need to be worked on since the last rains filled the reservoir almost to the crest, which may likely overflow its bank during years of excess rainfall and that may threaten the safety of the superstructure. Also, work is still ongoing on the irrigable area, but the extent of the work is not satisfactory.

Although community members are happy the project has finally come, they feel that the investment is not justified given a contract sum of above Ghc200,000, with lapses all around the project output. They also fear that the intervention may not yield the needed results sustainably due to the challenges. Hence, the need to move the contractor back to site to amend the lapses, particularly the perceived leakage. The height of the embankment and spillway should also be worked on.

Unlike the case of the Vunania dam where wider consultations were done with the involvement of local level actors and beneficiary communities, the execution of the Gia dam did not involve any of the stakeholders which is why the project is shoddily executed because there was no proper supervision.

Though the goal of the 1V1D was to build dams for small-scale irrigation and livestock watering, the water in the Gia dugout can barely meet up for livestock demand.

While the Vunania dam is uncompleted but quite useful, the Gia dam is completed but can not serve the intended purpose for which it was constructed.

4.2 Recommendation

The Vunania electoral area dam has the potential to create opportunities for livelihood enhancement activities such as dry season farming, and large-scale livestock rearing. This can result in reduced seasonal migration of the youth and the development of the community. However, lapses realized shortly after the construction of the dam may limit its potential. Specifically, an unknown source of water coming out of the ground that constantly soaks the area behind the embankment. Efforts must be made to establish the source of the problem by first examing the dam wall for signs of seepage such wall wetness. Secondly, excavating a trench of about 4x4m and 2m deep to trace the source by observing the direction of flow in. This can be done manually with ordinary tools like pick axe and shovel. Thirdly by draining the water, the impounded area can be observed to see if there are cracks indicating pure clay, or pourouse lining, since any of these cases can result in seepage.

Since water loss is meters away, possible seepage from the foundation, layers (beneath the heel of the embankment) can be minimized through the introduction of a cut off wall bellow the dam wall. The cut off wall is a deep trench dug along the upstream end of the embankment (heel) and filled with impermeable material such as clay and concert in some cases. This is the most recommended remedy because it reduces seepage through horizontal cracks, fissures and pervious seams in the foundation and it is also a long term solution.

It is also recommended that the height of gravel heaped towards the spillway from the impounded area should be leveled.

It must be noted that the water coming out of the ground is towards the edges of the valley (close to both ends of the embankment). Hence, when the water recedes beyond that point, the effect may cease therefore before the month of January is recommended as the best time for effective diagnosis to trace the source of the challenge and correct it. Beyond the month of February, the water may recede beyond the seeping point.

It was also observed that some of the farmers who started farming around the reservoir are too close to the water body and that can expose the reservoir to a high rate of sedimentation. It is therefore recommended that the buffer zone should be highly respected.

In the case of the Gia reservoir poor stakeholder participation resulted in poor execution of the project. It is recommended that rock boulders be used to line the dam walls and Vetiver grasses should be planted around the reservoir and behind the dam wall to trap sediment and help hold firm the dam wall material respectively. Also digging the other portions of the impounded area to the level of the highest depth will create room for more storage. Hence it is recommended that the Labour Intensive Public Works approach be used to uniformly increase the depth of the reservoir with a gentle slope.
The stakeholders made the following recommendations:

- The views of indigenous community members should always be considered from the planning through to the implementation stage.
- The heaps of gravel particularly towards the spillway area of the Vunania Dam should be leveled to allow water to spill freely when it gets to the FSL. Also the enbakment should be toped a bit with earth and leveled
- The beneficiary communities of the Vunania electoral area dam are calling on the Government to let the contractor return to address the weakness found in the execution of the project so far.
- Regarding the Gia dam, the approach used by the implementing institution does not allow room for accountability. Therefore, they recommend the bottom-up approach where the projects are decentralized and the local authorities take ownership of the projects within their jurisdiction and hence supervise to ensure value for money.
- Reservoir projects should always take into consideration past engineering surveys and designs especially if they are hinted by community members of existing marked locations. This also contributes to the satisfaction of the community members who are the final recipients of the projects.
- Instead of these small dugouts like the Gia one, next time funds should be aggregated for the construction of moderate reservoirs to store enough water for dry season irrigation as envisaged by the 1V1D program.
- Since GIDA is mandated to champion dam construction and its human resource have build experience and skills over the years, government should resource and motivate the institution instead of establishing parral institutions to do the same work.
- GIDA needs to be resourced with logistics (especially vehicles) to enable them conduct frequent monitoring of reservoirs under construction to ensure value for money.
- GIDA should be funded to conduct surveys to site possible locations for viable irrigation dams

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Appendix

Assessing the state, impact and sustainability of two reservoirs in the Kasena Nankane Municipal of the Upper East Region.

Questionnaire for Focal group participants

1 What is your gender:

Male ☐ Female ☐

2 How old are you?

18–24☐ 25–34 ☐ 35–49 ☐ 50–65 ☐ >65 ☐

3 How long have you been farming at the dam site?

0–1 years☐ 2–5 yea☐ 6–10 years ☐ Over 10 years ☐

4 Are you farming for yourself or taking care of someone farm

Own farm ☐ care taker ☐ Others ☐

5 How did you acquire the farm plot?

Bought rented demarcated others __________________

6 Do you have alternative livelihood

Yes no

7 Compared to your alternative livelihood, is farming more lucrative

Yes no

Explain ---

How many dependents in your household do you have? Leaving blank space equals 0 (zero) persons in that age group

Less than 1 year old: ___

11–17 years old: ___

1–5 years old: ___

18–65 years old: ___
6–10 years old: ___
Over 65 years old: ___
7 Aprt from farming how useful is the reservoir to you personally? ---------------------------------------
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8 What type of crops do you cultivate?
commercial crops like rice ? vegetables at large scale vegetables at small scale
specify ----------------
9 How much income do you obtain from farming?
50cd-100 150-300 350-500 550-1000 Don't know
10 How Do you apply water to your crops? Mark as many options as are applicable ?
? bucket and watering cane pumping machines and hoes by gravity others (specify)