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ARTICLE

The Potential of the Vunania Dam in Sustainable Agriculture in the Kassena Nankana Municipality of the Upper East Region

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Abstract

The northern regions of Ghana are characterised by a unimodal rainfall pattern, making rain-fed agriculture a difficult and precarious enterprise. Small-scale dam construction — capturing flash floods in the wet season for dry-season irrigation — offers a proven remedy. This study examines the state, impact, and sustainability of the Vunania electoral area dam, constructed with World Bank funding and managed by the Ghana Irrigation Development Authority (GIDA). Using a qualitative research approach comprising site visits, focus group discussions, expert interviews, and field observation, the study finds that the Vunania reservoir is a viable, community-valued intervention with significant potential across irrigation farming, aquaculture, livestock watering, and environmental amenity. However, three construction-related deficiencies — groundwater seepage behind the embankment, a low embankment relative to the high spillway elevation, and incomplete and uneven canal work — threaten the dam's long-term utility if left unaddressed. The paper argues that properly designed, well-constructed, and community-consulted small-scale dams are a critical instrument for agricultural productivity, poverty reduction, and youth retention in northern Ghana.

Keywords: *Reservoirs; Small-scale dam; Irrigation farming; Vunania; Kassena Nankana Municipality; Northern Ghana; Agricultural sustainability.*

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 pre-colonial times. A more organised system of irrigation dates to the period just before independence, which accelerated under the Land Planning and Soil Conservation Unit of the Ministry of Food and Agriculture. Following independence in the 1950s, the priority of water infrastructure development shifted toward large-scale dams and large-scale irrigation (Venot et al., 2011). The Asutsuare and Dawenya 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 (GIDA) was established by Supreme Military Council Decree 89 to oversee the development of irrigation infrastructure at appropriate scales for all communities.

Large-scale irrigation infrastructure has attracted substantial public investment across the developing world since the 1960s (Jones, 1995). While these investments have improved food security and reduced poverty in parts of Asia and Latin America, the same cannot be said of Sub-Saharan Africa (Rosegrant et al., 2002; Inocencio, 2007). Large-scale irrigation schemes in Africa are publicly managed, and farmers are frequently the recipients of decisions that impoverish rather than enrich them (Williams, 2007). Enrichment through corruption does not end with construction; it extends to local irrigation officials (Rijsberman, 2005). This has periodically led to conflicts between farmers and management, and has compounded concerns over displacement, inadequate compensation, and environmental damage — as in the case of the Vea scheme in the Upper East Region (Konings, 1986).

Moreover, large-scale irrigation schemes in Sub-Saharan Africa have chronically underperformed, generating debate about whether investing in such infrastructure is warranted (Williams, 2007; Wallace, 1979). FAO (2005) data shows that approximately 18% of developed hectares in large-scale schemes are underutilised, while revenues have rarely recouped construction and maintenance costs (Diemer, 1988; Faures et al., 2007). In Ghana specifically, poor management and operational challenges have severely limited the contribution of these schemes to rural livelihoods (Acheampong et al., 2014).

These failures shifted policy attention toward small-scale irrigation infrastructure. Small reservoirs and dugouts require comparably little capital, can be sited closer to target communities, and reach a wider population across a region (Liebe, 2002). Critically, small reservoirs place indigenous farmers in full control of water management, resulting in higher crop yields and greater women's participation (Ofosu, 2012). Between the late 1950s and early 1970s, demand for dry-season water triggered the construction of approximately 240 earth dams and dugouts in Northern Ghana (Namara et al., 2011). By 2008, approximately 3,392 small dams and dugouts were serving around 6,000 hectares across Ghana, of which some 149 dams and 129 dugouts were in the Upper East Region alone.

From the 1990s, investment in small reservoirs and dugouts became largely donor-driven, led by the World Bank Village Infrastructure Project, the IFAD Upper West Agricultural Development Project, and Phases I and II of the Land Conservation and Smallholder Rehabilitation Project (LACOSREP). Under LACOSREP, 100 small reservoirs were rehabilitated in the Upper East Region from 1990. Crucially, the FAO, World Bank, and International Water Management Institute (IWMI) recognised during this period that poor performance was often attributable not to farmer negligence, but to the failure of implementing institutions to incorporate indigenous knowledge and local socio-cultural context into design (World Bank, 2004; GIDA, 2010). This insight is central to evaluating the Vunania dam.

2. EVOLVING POLICIES FOR RURAL AGRICULTURE IN GHANA

Despite progress in small-scale irrigation, major causes of underdevelopment in Northern Ghana continue to be attributed to poor irrigation infrastructure (Adongo et al., 2017; World Bank, 2017). As donor investment in reservoirs has dwindled (Williams, 2007), successive governments have introduced programmes to address this gap. The most prominent recent initiative is the 'One Village, One Dam' (1V1D) project, launched in 2018 with the aim of constructing 570 small earth dams across the five northern regions at an average cost of GHS 250,000 each (Graphic Online, 2019; Parliament of Ghana, 2019).

Community expectations of 1V1D were high — the dams were envisioned as enablers of year-round farming, domestic water supply, and youth employment, arresting the dry-season drift of young people southward in search of work (Adam et al., 2016). The reality fell short. When dams were constructed, they proved too small and too shallow to sustain dry-season gardening; most dried up before February, when water is most needed (Joynews, 2021). Available storage met only livestock and domestic needs. The 1V1D experience reinforces a lesson that the literature has repeatedly demonstrated: without proper feasibility studies, sound engineering, and community consultation, irrigation infrastructure becomes a nine-day wonder at best, and a white elephant at worst.

There is a dearth of post-construction analysis of newer small reservoir projects. Pre-construction design and post-construction evaluation are equally important: such evaluation can inform policy on the justification of public expenditure and provide a lens for assessing sustainability against intended aims. The Vunania dam, funded by the World Bank and constructed by GIDA, offers a timely case for precisely this kind of assessment.

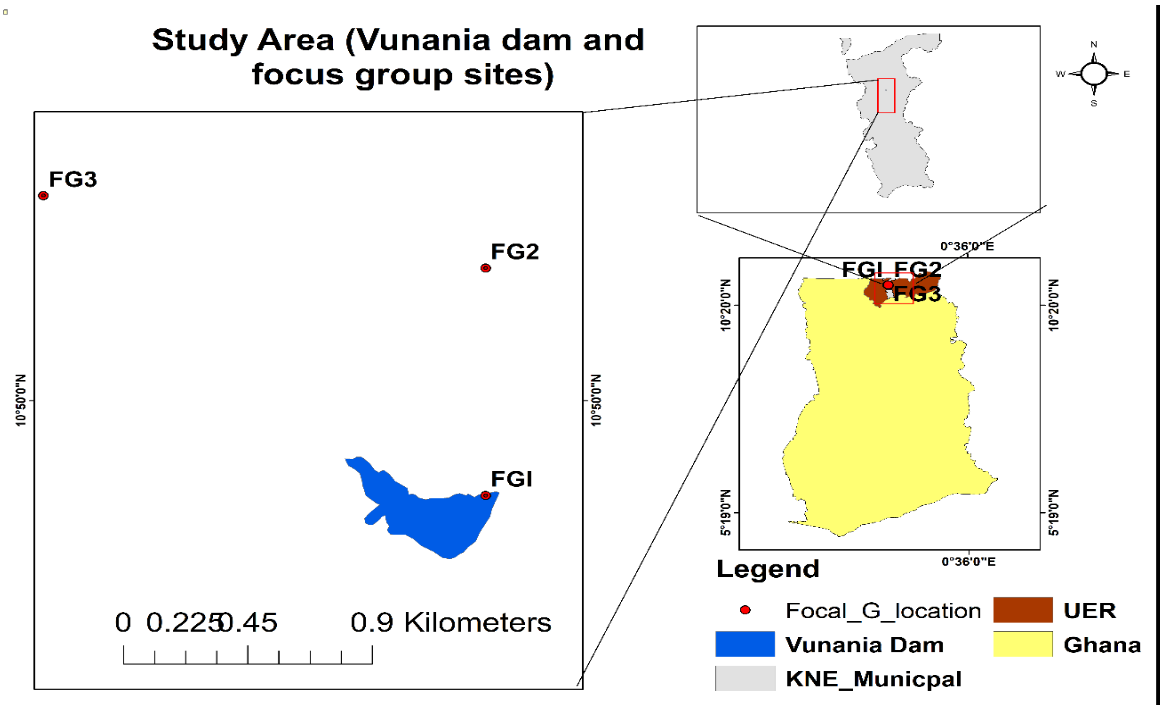
3. STUDY AREA AND METHODOLOGY

Study Area

The Vunania electoral area reservoir is situated in the Upper East Region of Ghana (10.83°N, 1.059°W), covering the communities of Vunania, Ghani, Janania, and Bundunia over an area of 305 km². This savanna ecological zone is characterised by significant temperature variations and a unimodal rainfall pattern with three seasons: a rainy season (July–September), a dry season (February–May), and the Harmattan (November–January). Annual rainfall ranges from 850 mm to 1,245 mm, with more than 80% concentrated in the rainy season. Monthly surface temperatures range between 27°C and 38°C. The major soil types are vertisols, luvisols, lithosols, and arenosols.

The area is predominantly agrarian; the long dry season leaves many residents without productive activity, driving seasonal migration.

Figure 1: Location of the Vunania Dam and Study Area



Source: Field survey data. The map indicates focus group locations and the Vunania Dam boundary within the Kassena Nankana Municipality, Upper East Region.

Figure 2: Google Earth Image of the Vunania Reservoir

Aerial view of the high-elevation section of the Vunania reservoir showing the impoundment area and surrounding catchment.

Methodology

The research employed a qualitative approach consisting of focus group discussions, expert interviews, key informant interviews, and direct field observation. Field visits to the dam site enabled the observation and assessment of key structural components: the dam wall, spillway, catchment area, canal works, and surrounding farming activities. Point elevations were taken to support analysis. Interactions with GIDA and Ministry of Food and Agriculture (MoFA) engineers were undertaken to verify field observations and elicit technical perspectives on the dam's condition.

Three focus group sessions (FG1, FG2, FG3) were conducted between December 2022 and January 2023, with a total of 33 participants. FG1 comprised farmers at the dam site; FG2 consisted of opinion leaders including the Chief, Landlord, Assembly man, Youth Leader, and two elders; FG3 was the women's group raising seedlings for afforestation downstream. All sessions exceeded the minimum participant threshold for productive group dynamics (Sim, 1998; Mclafferty, 2004). Sessions were guided by a topic guide with sub-topics, follow-up questions, and probes, with moderators applying mild, unobtrusive control to prevent group domination (Nyamathi and Shuler, 1990).

Figure 3: Focus Group Discussions Conducted at Three Locations

Focus group sessions with dam-site farmers (FG1), community opinion leaders (FG2), and the women's seedling group (FG3).

Prior to discussions, participants completed a brief demographic survey covering age, gender, farm ownership, livelihood sources prior to dam construction, and income from irrigation farming. Audio recordings and raw transcriptions were screened for broad themes (Nicholls, 2017), then coded using thematic descriptors refined across multiple review cycles and validated by a third party.

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 own farmland
FG2	5/1/2023	Vunania chief's palace	6 / 0	3 own farmland
FG3	7/1/2023	Vunania township	1 / 8	4 own farmland

Table 2: Analytical Themes and Thematic Descriptors

Theme	Thematic Descriptor
General thoughts on reservoirs	Participants' perceptions of reservoir infrastructure and their level of satisfaction with the facility
Perceived benefits and barriers	Benefits perceived from the dam's presence and barriers likely to hinder their full realisation
Sustainability and perceived threats	Participants' views on how sustainable the reservoir is and how to address threatening factors
Community role in sustainability	Participants' own contributions toward the reservoir's long-term viability

4. BACKGROUND TO THE VUNANIA ELECTORAL AREA DAM

The Vunania valley has a long history of organised agricultural activity. In the 1950s, the Agriculture Department ran a co-operative farming project in the valley, ploughing fields and allocating plots to women from Janania, Ghane, Bundunia, and Vunania — a group known as the 'Makazia.' Recognising the potential for a dam to enable dry-season farming, the Land Planning and Soil Conservation Unit of the Ministry of Agriculture conducted a feasibility study between 1960 and 1965, identified a suitable site, and planted pillars marking the construction point. The 1966 coup interrupted the process. Community members waited fifty years.

In 2019, GIDA secured World Bank funding to execute the project. The community's elation was significant: the dam represented not just a water infrastructure investment, but the belated fulfilment of a promise made in the early years of independence. Yet the siting decision would prove contentious. One conspicuous theme emerging from focus group discussions was that the dam was not constructed on the site originally identified in the 1963 surveys.

> *"We have lived here all our lives, and we have the knowledge of the water ways and local geology of the area, but when we made our submissions they did not utilise 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."*
>
> **— Elder, Vunania community**

The Chief was equally direct:

> *"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."*
>
> **— Chief, Vunania**

The current reservoir location impounds water from one valley only, whereas the originally marked site would have impounded water from three converging valleys, yielding significantly greater storage capacity and irrigable area extending to Golgo and Naaga. Community members are disappointed by the missed potential but remain broadly supportive of the project.

5. CHARACTERISTICS OF THE VUNANIA DAM

The Vunania dam is fed by a 52-hectare catchment area. Its structural specifications classify it firmly within the small reservoir category as defined by GIDA (1995): a full-scale storage area of 15 ha, maximum depth of 7 m, embankment length of 470 m, storage capacity of 12 Mm^3, and a concrete channel spillway connected to one end of the embankment. The inner face of the embankment is boulder-lined to deter crocodiles and other reptiles from burrowing. Vetiver grass has been planted at the catchment periphery to trap sediments and reduce reservoir siltation, and trees are being raised for planting within the buffer zone.

The dam is designed to serve a 15-hectare irrigable area downstream. Water abstraction is via an outlet connected to an inlet chamber through a conduit pipe in the impoundment, linked to a distribution point fitted with control valves. Water is to be conveyed to irrigation fields by gravity through closed pipes — preferred over open canals for their lower evaporation and seepage losses. At the time of fieldwork, the irrigation facility remained under construction. A small number of farmers were cultivating at the upstream end using motorised pumps, buckets, and watering cans, on plot sizes ranging from 0.01 to 0.05 ha, totalling approximately 1.5 ha of irrigated vegetables — tomatoes, pepper, and leafy greens. Upon completion of the canal system and gravity-flow infrastructure, farmers expressed strong confidence in their ability to significantly expand farm sizes.

6. BENEFITS OF THE VUNANIA DAM

Though the Vunania dam has been impounding water for only three years, focus group participants across all three groups articulated wide-ranging and already-tangible benefits. These were grouped into economic, social, and environmental categories.

Environmental Benefits

Participants living close to the reservoir noted a marked cooling effect during the dry season, particularly in March when heat had previously been severe. The presence of a permanent water body has also made the area more attractive for settlement, with new houses being constructed nearby.

> *"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."*
>
> **— FG1**

> *"Due to the area's distance from water sources, initially only a few people built around here, 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."*
>
> **— FG2**

Economic and Livelihood Benefits

The dam has directly stimulated livestock rearing. Participants reported reduced livestock losses, improved animal health (attributed to close and reliable water access), and diversification into pig rearing — an enterprise that has helped families meet school fees and other household costs. The proximity of the dam to community land — in contrast to the distant Tono irrigation scheme — has enabled farmers to engage in multiple livelihood activities within a single day, combining farming with livestock management, beekeeping, and childcare in ways previously impossible.

> *"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."*
>
> **— 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 am able to 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 beehive and still come back to the farm."*
>
> **— FG1**

Seasonal migration is a direct consequence of the unimodal rainfall pattern that leaves the dry season economically barren. Focus group participants cited the dam as a structural remedy:

> *"The unimodal rainfall pattern limits us to one season cultivation (June to October) in the year and throughout the dry season we have nothing to do except those who can obtain a plot at 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 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."*
>
> **— FG3**

These accounts are consistent with Adam et al. (2016) and Akudugu et al. (2016), who found that out-migration and poverty rates were substantially lower in communities with irrigation infrastructure than in those without. Additional uses cited across all groups include fishing, construction water supply, and raw water sales to neighbouring communities.

Figure 4: Farming at the Upstream Area Close to the Dam

Farmers cultivating vegetables at the upstream end of the Vunania reservoir. Proximity to the dam facilitates multi-activity livelihoods but risks sedimentation if buffer zones are not enforced.

7. PERCEIVED THREATS AND SUSTAINABILITY OF THE VUNANIA DAM

Community expectations of the dam are substantial, and the dam has already begun to deliver. But focus group discussions, key informant interviews, and field observation identified three structural challenges that, if unaddressed, could materially undermine the dam's long-term value.

7.1 Groundwater Seepage Behind the Embankment

The most concerning finding was water emerging from the ground at the downstream end behind both ends of the dam wall — clean water flowing visibly on the surface and keeping the ground wet up to a mile away. Community members attribute this to improper compaction of the embankment's foundation layers, citing direct observations during construction:

> *"The reason why we are of a strong view that the water is seeping from the dam through the dam wall 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."*
>
> **— Assembly Man, Vunania**

GIDA engineers, however, note that the water is emerging several metres from the toe of the embankment and is clear — not turbid as would be expected if the dam wall were actively eroding fine particles (Kazemzadeh-Parsi and Daneshmand, 2011). Their preferred explanation is either activation of dormant springs due to impoundment pressure, or water percolating through porous rock formations beneath the valley. As reservoir pressure fills these pore spaces over time, the flow may naturally reduce (Pham et al., 2013). The finding that the seeping water is within the planned irrigable area may partially offset the loss by providing natural sub-surface irrigation for downstream plot-holders.

Regardless of cause, the condition requires early geotechnical investigation. Allowing seepage to continue without diagnosis risks progressive structural compromise of the embankment, particularly at the ends where both community observation and engineer inference suggest inadequate compaction (Özer and Bromwell, 2012).

Figure 5: Water Oozing from the Ground Behind the Vunania Dam

Groundwater emerging at the downstream end of the Vunania embankment. The clarity of the water indicates percolation through porous rock rather than dam-wall erosion, but geotechnical investigation is required.

7.2 Low Embankment Height Relative to Spillway Elevation

Field observation and elevation measurements revealed an imbalance in the dam's hydraulic design. The spillway end of the impounded area stands at an elevation of 247 m above sea level, while the opposing end sits at 228 m. The embankment is also slightly low. During the second year of impoundment, floodwaters rose to near the top of the embankment, necessitating emergency breach of the spillway to release water — which has since been repaired but remains structurally high. In very wet years, overtopping is a realistic risk.

A heap of gravel on the left bank near the spillway further obstructs outflow, impeding natural drawdown to the full supply level. The relatively shallow valley depth, except near the dam wall, also increases vulnerability to evaporation. Community members and the engineers both recommend: (a) increasing embankment height, (b) levelling the gravel heap at the spillway to allow free flow, and (c) excavating the impounded basin to increase storage depth and reduce evaporative surface area.

Figure 6: Spillway and High Elevation of the Impounded Area

The elevated spillway relative to the low embankment creates an overtopping risk in years of heavy rainfall. Levelling the gravel heap and raising the embankment are priority remedial works.

7.3 Incomplete and Defective Canal Works

Work on the 15-hectare irrigable area downstream was underway at the time of fieldwork, but sections of the canal were broken and the alignment was irregular. Community members and the Assembly man expressed concern that construction quality mirrored the deficiencies in the dam itself:

> *"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."*
>
> **— Assembly Man, Vunania**

The chiefs and community members appealed directly to the Government to intervene — ensuring that the contractor returns to remedy deficiencies so that the dam does not become the 'white elephant' they fear. A total contract sum exceeding GHC 200,000 makes this concern about value for money particularly salient.

Figure 7: Canals in the Vunania Irrigation Area Showing Defective Construction

Incomplete and misaligned canal sections in the Vunania irrigable area. Community members requested heightened GIDA supervision to ensure the irrigation facility meets intended design standards.

7.4 Buffer Zone Enforcement

A further sustainability concern, observable in the field, is that some farmers have established plots too close to the reservoir — within the 30-metre buffer zone that should be maintained to control sedimentation. Farming within the buffer accelerates reservoir silting, which over time reduces storage capacity and shortens the dam's useful life (Atulley et al., 2022). Community members acknowledged awareness of the restriction and committed to enforcing it, but requested continued technical guidance from GIDA.

8. CONCLUSION AND RECOMMENDATIONS

The Vunania electoral area dam represents the fulfilment of a community aspiration that dates to the early years of Ghanaian independence, deferred for half a century by political disruption and funding constraints. Its construction has already generated tangible economic, environmental, and social benefits: year-round water availability for livestock and domestic use, dry-season vegetable farming, environmental cooling, fishing, construction water supply, and the beginnings of an end to seasonal youth migration. These benefits are consistent with the broader evidence base on small-scale reservoirs in northern Ghana (Adam et al., 2016; Akudugu et al., 2016; Faulkner et al., 2008).

The study also confirms what the literature has long established: that the failure to incorporate indigenous knowledge and earlier engineering surveys into siting and design decisions leads to suboptimal outcomes. The dam's location — away from the three-valley confluence identified in the 1963 surveys and insisted upon by community elders — has limited its storage potential. The construction deficiencies in the embankment compaction and canal works are consistent with inadequate supervisory oversight during construction, a recurring challenge in publicly managed irrigation infrastructure in Sub-Saharan Africa.

Properly designed, well-constructed, and community-consulted small-scale dams remain a critical instrument for agricultural productivity and poverty reduction in northern Ghana. The Vunania dam has significant unrealised potential. Realising it requires prompt remedial action and sustained institutional engagement.

Recommendations

- The contractor should be required to return and address the three identified structural deficiencies: the seepage condition (following geotechnical diagnosis), the embankment height deficit, and the canal misalignment and breakages.
- The gravel heap near the spillway should be graded and levelled to allow free outflow at full supply level, reducing the risk of embankment overtopping in high-rainfall years.
- A geotechnical investigation should be completed before the end of January, when the seeping water is still at or above the diagnostic point, to determine whether the cause is dormant spring activation, porous rock percolation, or inadequate compaction — and to prescribe the appropriate remedy.
- The 30-metre buffer zone around the reservoir should be clearly demarcated, grassed, and enforced, with GIDA providing technical support to community members in monitoring and upkeep.
- All future reservoir projects in the region should systematically consult GIDA's archive of historical engineering surveys (including the 1963 site assessments) alongside participatory consultations with host communities, whose indigenous knowledge of hydrology and local geology should be treated as primary evidence, not supplementary input.
- GIDA should establish a post-construction monitoring and maintenance schedule for the Vunania dam, with defined intervals for structural inspection and community liaison, to prevent deferred maintenance from compounding construction-stage deficiencies.

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