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Community water infrastructure and the One Village One Dam Project: A case study of the Gia dam in the Kassena Nankana East Municipal District

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Abstract

Water storage has a vital role to play in improving food security and reducing poverty , particularly in the geographical context of northern Ghana that is characterized by short unimodal rainfall pattern . A wide range of storage structures are available with the commonest being dams. While the positive effects of large dams have not been thoroughly utilized, the special appeal of small water infrastructure makes them more preferred . Despite the focus on construction of smaller dams in some parts of northern Ghana , not all of them remain functional . While some are defective and silted , others are not well engineered , particularly , the Gia dam in the Kassena Nankana East Municipal District in the Upper East Region . Consequently , they are not able to serve their intended purposes . This paper is a case study of the Gia dam constructed under the One Village One Dam [1V1D] initiative and provides empirical evidence to inform current and future dam construction . The study examines the shortcoming of the execution of community dams and argues that the planners need to consider re - engineering and correct defects in the already constructed reservoirs . Community driven and better managed dams with private sector led financing of rural water infrastructure projects would facilitate adequate water for all year - round farming and other domestic activities . Alternative construction models are proposed for implementation.

Keywords: *Reservoirs; Agriculture; Small Scale Dams; One Village One Dam; Gia; Ghana*

1. Introduction

Conservative estimates by the United Nations Food and Agriculture Organisation (FAO) indicates that over 70% of freshwater extracted globally is utilised by the agricultural sector, while industry account for 12%, and the remaining 18% is used directly for human consumption. At this rate of use, The FAO estimates that by 2050, agriculture will have to produce almost 50% more

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food, fibre, and biofuel to meet global demand; a goal that will be difficult to achieve without increasing the area devoted to irrigation.

In Ghana, water stress in the northern sector of the country tend to impact on agricultural productivity and livelihoods. While the rainfall pattern is bimodal in the south, it tend to be mono-modal in the north and the northern parts have higher water deficits due to the high evapotranspiration (Bessah et al., 2021), resulting in huge water deficits for plant growth. Given the direct relationship between water and improved livelihoods (Abanyie et al., 2023), the northern part of Ghana is known to be the country's hotspot for hunger and poverty (Faurres et al., 2007). Consequently, irrigation should be central to any policy aimed at improving rural livelihoods and survival and stemming the tide of the rural folk flocking into the cities for non-existent jobs, as well as balanced development of the countryside. The case for irrigation in northern Ghana has been made strongly in studies such as Alagidede et al (2023) and Agodzo et al (2014) and the references therein.

Climate change associated with natural variability, short duration, and reduction volumes of rainfall in most places makes access to fresh water unpredictable. For smallholder farmers, the difference between plenty and famine hings on reliable access to water. The definite response is to construct reservoirs to capture flash floods in the rainy season for irrigation purposes in the dry season. More than 45, 000 large dams (dam walls more than 15m high) have been built throughout the world and the majority of these are in North America, China, and Europe out of which 40% are used for irrigation. Large irrigation reservoirs have also received huge public investments in the developing world. 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 (Hussain, 2005). This is the case because, the potentials of large reservoirs are underexploited. Although large dams contribute significantly to economic development, the controversy surrounding their effectiveness for irrigation in Africa led to a reduction in investment and a shift to small dams . There are concerns of (i) Negative environmental impacts where river ecosystems and wetlands downstream are affected by dam construction ; (ii) Social impacts of more residents being displaced due to the large area they cover e.g. the Vea scheme ; (iii) management lapses where irrigation scheme managers prioritize their own needs and those of influential strangers with lands in the project 's site over those of indigenous farmers (iv) underutilization and associated low revenues which have, neither fully recouped the high investment costs nor the operations and maintenance costs of large irrigation infrastructure (William , 2007). These bottlenecks put a big question mark on the economic viability , generating debates on whether investing in large-scale irrigation infrastructure is worthwhile for irrigation development especially in northern Ghana.

Amidst the ineffectiveness of large dams, water infrastructure is still needed to safeguard people's livelihoods and the environment, hence a gradual shift towards the development of small reservoir infrastructure (Chambers 1988; Merrey, 2002). The special appeal of small reservoirs is that; (i) their construction requires comparably little expenditure (ii) they represent an adequate tool to manage freshwater storage (iii) they spread throughout an area and reach a wide population (iv) they are better managed and they tend to give indigenous farmers full control over the water. Hence , small dams can make a major contribution to rural livelihoods.

From a cost-benefit analysis perspective therefore, there has been a shift towards the construction of small reservoirs for irrigation as they hold a great deal of rewards for communities vis-à-vis large-scale projects. On this score, the Government of Ghana in 2018 set out to construct more small earth dams under the one village one dam (lV1D) project, to make water available to a wider rural population of Northern Ghana for all-year -round irrigation . However , without proper consultation and sound engineering such interventions in most cases have become unsustainable with a good example being the Gia dam, the subject matter of this article.

2. Impact of small dams on rural livelihood

Small multipurpose reservoirs are an age-old adaptation to living in dry areas with highly variable rainfall (Venot et al., 2011). Ghana and Burkina Faso are notably good examples of rural communities maximizing economic returns from small community reservoirs.

The small earth dams offer several advantages, including:

a) Water storage: One of the main advantages of small earth dams is their ability to store water. They can collect and store runoff water during rainy seasons for drinking, local construction and other domestic activities in periods of drought or low rainfall.

b) Irrigation: Small dams can be used for irrigation and to provide a controlled water supply for other agricultural activities. This can ensure all year-round farming, especially for high value crops such as vegetables, fruits and other esthetic crops contributing to increase crop yields, improve agricultural productivity, create jobs and maintain food and nutritional security.

c) Flood control: Small earth dams can help alleviate flooding in areas prone to heavy rainfall or flash floods. By capturing and storing excess water, they can reduce the risk of downstream flooding and mitigate potential damage to nearby communities and infrastructure.

d) Reservoir for livestock and wildlife: Small dams can serve as water reservoirs for livestock and wildlife. By providing a consistent water source, they support the wellbeing of animals and enhance the ecological balance of the surrounding area.

e) Soil conservation: The construction of small earth dams often involves terracing and contouring of the land, which helps to control soil erosion. The dams can retain sediment and prevent it from being carried away by water, thus conserving the fertility of the soil. When earth dams are filled, they can facilitate the recharge of groundwater reserves. As water seeps into the ground, it replenishes underground aquifers, contributing to the long-term sustainability of water resources.

f) Recreation and aesthetics: In addition to their functional benefits, small earth dams can also enhance the natural beauty of the landscape. They can create scenic water bodies that can be enjoyed for recreational activities such as fishing, boating, or simply appreciating the surrounding environment.

g) Aqua culture and other aquatic activities. Small each dam in most cases creates opportunities for shrimps and fish farming which provides protein needs for local communities and ensuring food and nutritional security.

Generally, small functional community dams in Northern Ghana are said 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 during the long dry season. Due to the far reaching benefits of these small earth dams, several investment in sub-Saharan Africa over the past century have been directed towards their development (Staatz and Dembélé, 2008). Unfortunately, some of these dams are defective, silted, or not well-engineered, limiting their economic and socio-cultural potential. These limitations could cost the local economy a close to a quarter of its growth potential. The Upper East Region case is a good illustration of the urgent need for appropriate intervention in the rehabilitation of reservoirs to increase agriculture productivity.

3. Methodological approach to studying the Gia dug out under 1V1D

This is a phenomenology and focus group study. Field visits to the Gia dug out was conducted between December 2022 and January 2023. Field observation enabled us to gain a firsthand view of the setting. The key components of the dugout, such as, depth, activities around the reservoir, the wall structure, and the irrigation area were taken to aid analysis. Interaction with experts from the Ghana Irrigation development Authority (GIDA) and the Ministry of Food and Agriculture (MoFA) were undertaken to verify certain conclusions from field observation and to understand the state of the dug out from their perspective.

In the focus group discussions , the moderators shared the basic ground rules , while participants were assured that the research team were seeking to learn from personal and lived experienced of the community . They were encouraged to share their views and experiences without repercussion or judgment . The moderators sought verification and validation from participants . Upon receipt of verbal concept , sessions were recorded and transcribed . 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 (Janice et al., 2002); (Suri et al., 2009). Focus groups were steered by a topic guide , subtopics , follow-up questions , and probes . During discussions, the moderators applied what Nyamathi 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 comprising ten multiple-choice questions . Questions examined ages of participants and all household members , gender , farm ownership , and number of years farming in the location . Participants were also asked to state where they derived their livelihood from prior to 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 (Reimer , et al., 2010), 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 allowance for participation.

4. Analysis of the findings: The Gia dam out

Currently , there are about 300 community dams in the Upper East Region that help to reduce over-reliance on rain-fed subsistence agriculture , however , not all of them are functional . The Gia dam was constructed in 2019 under the 1V1D 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 (see figure 1) using bulldozers and excavators to create the embankments (see Plate 1). The Gia reservoir has a storage capacity of 2 x10^4 m^3 in a very flat valley with the highest depth of 3m but overall average depth is about 1.5m.

The impoundment has an embankment length of about 150m, maximum depth of 3m. The embankment is not constructed with boulders like the embankments of small reservoirs, and it has no spillway. In short, the structure is not well engineered . According to Ofosu (2012), impoundments with embankment length ranging from 30m to 314m, maximum depths ranging from 0.7-3.0m, full supply level reservoir area from 0.04-3.2ha and storage volume of 4x103 m3 to 64x103 m3 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 . 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), made a similar observation in other dugouts constructed under the 1V1D project (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 lack officially developed irrigable areas. While other dugouts have reasonable, storage and farmers develop their field 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 is not serving its intended purpose (see PFAG , 2020; Graphic online, 2022).

The success of small-scale water projects depends crucially on support from local beneficiary community members. In the Gia case, community members indicated that they were only informed of the project but were not involved in its execution. Some of the community members had this to say;

> "if they had put together the money they used for the Ka jolo and Gia dugouts to construct one reasonable storage system in a suitable location it would have

been better off". "the news of the intervention actually heightened our expectation but when the project was finally delivered, we became sad because our expectations are not met".

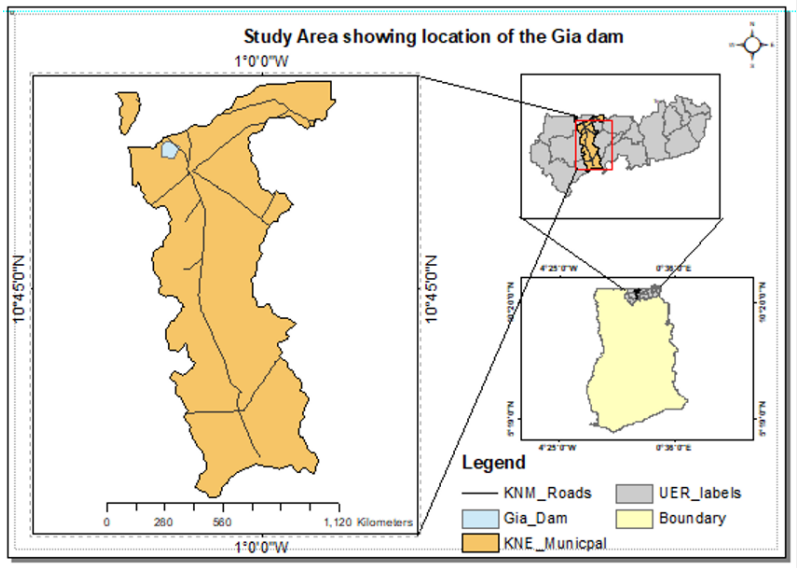

Figure 1. Location map of the study Area (Gia dam)

Meanwhile according to (Embaye et al., 2020), 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 phase , they would have pro - posed aggregating several dugouts to construct one reasonable dam at a suitable location to serve the local community . This view is highly realistic given that the fragmentation with the current conception and roll out of the 1D1V initiative results in waste of public resources. Additionally , in a resource constrained environment, one good well-constructed dam yields higher utility compared to several dugouts which are not well constructed and managed.

Involving technocrats in the project design through to the implementation phase is equally key to the success of small-scale irrigation projects. The engineers in the Municipal Assembly and GIDA were not involved particularly in the implementation stage, hence the project execution lacked a touch of professionalism. The lapses we see in the project are therefore not surprising. Similarly, a research team from GIMPA and PFAG looked into the 1V1D initiative and reported that most reservoirs constructed under the Government's flagship program are not serving the intended purpose. This they attributed to poor siting and noninvolvement of key stakeholders including the local communities, the Municipal Assembly and GIDA in the conception and implementation of the project (PFAG, 2020; Graphic online, 2022).

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 was engineered locally with community labour and minimum financial motivation and food for labour approach by an NGO 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 until recently. 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 safety net project with supervision from GIDA for construction and maintenance of small earth dams with accompanying irrigation facilities (Nyanyofio et al., 2022). The Safety net project that evolved from the GSOP project is a Labour-Intensive Public Works (LIPW) created under

Figure 2. Source: Author Field Survey (2023)

the Ministry of 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 to use 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 serve as a livelihood support system for them while they still contribute to creating an asset for the community (Devereux, 2002).

5. Critique of policy approach and recommendation

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 hurdles in these early days could save substantial public resources from going down the drain. At the same time, Ghana should take several steps to ensure community dams are constructed devoid of these bottlenecks and managed sustainably. To this end, the following steps are needful.

5.1. Re-engineering of the dams under 1V1D

The current state of the Gia dam reflects the state of most of the dams constructed under the 1V1D. The reservoir cannot store enough water for livestock watering all year round . The primary objective of meeting the needs of small-scale irrigation farming is heavily compromised with the poorly designed and executed 1V1D dam. Without alternative robust dams and improvement in the existing ones , many rural communities which are already water deprived could suffer undue hardship when solutions exist. With respect to the current Gia dam a uniform excavation of the reservoir to the deepest depth is highly recommended to create room for more water to be stored . The engineering and construction parameters ought to be thoroughly assessed. The excavation should have a gentle slope to make it safe for livestock watering . Engaging the local people and the relevant stakeholders (GIDA , MoFA and MDA 's) would ensure standard execution and judicious use of public funds. A well-executed reservoir will ease the burden of farmers in the community.

This study failed to ascertain detailed draft plans and the cost-benefit analysis that preceded the construction of the dams, a good avenue for future research to explore. In the absence of data on the parameters for comparative analysis the study relied on the monetary cost.

The investment cost for small scale irrigation reservoirs in Semi-Arid Regions were evaluated at $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; Bekoe et al., 2021). The minimum amount allocated for the construction of each dam under the 1V1D was GhS 250, 000, bearing in mind that the stated figure and what actually get to the ground may vary by a wide margin.

At the time most dams were constructed (2019-2020), the exchange rate was about GhS11=$1 implying that each reservoir was allocated $23,000. Given inflation and exchange rate effects that would amount to about $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 projects execution in Africa (Hasty, 2005; Venot et al., 2011; Brierley, 2017).

The numerous horizontal relationships between bidders in public contracts who conspire to stifle competition, bid rigging in a public sector riddled with inefficiency and severely damaged institutions amplifies rent seeking and ensures that only a quarter of the funds allocated get used in the project. This conclusion using the Gia example is self-evident. We therefore echo the conclusions of earlier writings such as Lasage and Verburg (2015) on the fact that other factors such as failure to use mandated institutions for project execution, politicisation and lack of technical know-how contribute more to the abysmal output of the Gia reservoir as well as the other projects under the 1V1D.

5.2. Creation of a national coordinating mechanism for community dam construction and management.

Most of the dams constructed under the 1V1D have lapse similar to those uncovered in the Gia project attributable to the approach employed in project implementation. "The Government's approach adopted for the implementation of the 1V1D was to establish a parallel institution (Special Development Initiative) which then directly engaged a private consultant without involving key stakeholders in the field who have the technical know-how and experience. Meanwhile, GIDA is mandated by law to oversee the development of irrigation infrastructure in Ghana and its human resource have built experience and skills over the years. Hence, government should have resourced and motivated GIDA instead of establishing parallel institutions to do the same work.

Moreover, broader consultation of all stakeholders was missing in the 1V1D project. Hence every project within the jurisdiction of community dams should involve all relevant stakeholders at the National and local levels of Government such as MoFA. The beneficiaries' community leaders and members are also critical if investments in small community dams will yield significant and sustainable impacts in improving food security and poverty reduction.

Furthermore, Ghana could benefit from creating a high-level, interagency mechanism with representatives from the primary departments concerned with different aspects of water storage systems. The primary function of this mechanism should be to coordinate policy efforts toward strong adherence to the requirements for the construction of community dams so that Government does not bypass working institutions to work with individuals on community dam projects. The mechanism should also identify national strategic priorities to guide local officials and provide guidance to reservoir managers. It should also ensure persistent checks and balances on community dam projects to ensure proper construction and maintenance of the reservoirs. This mechanism could take several forms: committee, council, a*d hock* working group, or a joint conference platform.

5.3. Establish and implement water management by-laws

In some countries, by-laws serve as the foundation for water governance. The challenges of locating farms very close to reservoirs tend to threaten their potential from siltation. The buffer by-laws should be clearly defined, and the institutional mechanism for enforcement strengthened. There is a need to provide a legal foundation including a more effective role for community leadership. It is also important to clarify the allocation of powers and responsibilities in the implementation of small reservoir development and management. This can include who is to construct the reservoirs and who is responsible for grassing the reservoir buffers and for enforcing the laws to prohibit farming within the buffer boundary to curtail sedimentation.

5.4. Post-construction analysis and evaluation to identify and correct defects

Dam defects when detected early and corrected will preserve the dam structure from deteriorating further. Correcting the defects left by the initial construction is highly recommended. Just as the pre-construction and design of small community dams are crucial, post-construction analysis is critical. This will provide a lens for assessing the sustainability of the project against the intended aims, justifying public expenditure on the infrastructure or otherwise.

6. Financing the construction of small-scale irrigation dams

Government agencies often provide funding for infrastructure development projects, including small-scale irrigation dams. The experience of Ghana's experiments in large- and small-scale irrigation projects indicates that grants and subsidies available from local, regional, or national government bodies for irrigation projects have not been efficient in closing the water deficits to improve agricultural productivity in farming communities. A plethora of government funded projects are ill conceived and poorly constructed (see Gia dam) thereby limiting their usefulness to the beneficiary communities. Another avenue of funding is through development aid and international organizations. Aid programs may offer financial assistance for irrigation projects through the World Bank, or regional development banks. This avenue of funding comes with strings, and the fungibility of aid ensures that the intended benefits are not fully utilized.

Alternative avenues for funding sustainable small-scale irrigation projects via crowdfunding or community financing is therefore highly recommended. Depending on the scale and impact of the project, crowdfunding platforms or community initiatives may be viable options. Engaging with the local community and seeking their support through donations or investments can help finance the construction. This keeps the project at the local level and firmly embed development within the psyche of the people.

Forming partnerships with private entities can provide the necessary financial resources for the pro ject . In Public Private Partnership arrangements , the government and private investors collaborate to fund and operate the irrigation dam in exchange for specific benefits or revenue -sharing models.

Taking the structural parameters and the state of the dam the completed project qualifies as a dugout which with some fine tuning could have produced a higher output dam . In environments of budget constraints , one prudent avenue of accomplishing a viable dam would be the Labour - Intensive Public Works (LIPW) approach . The division of labour for such an exercise would be one in which the Gia community supplies labour with some form of financial motivation to build and rehabilitate reservoirs with supervision from sector institutions such as the District Department of Agriculture . The Ghana Safety net pro ject successfully used this approach to rehabilitate some community dams in Northern Ghana , which is worth emulating . Given the inefficiencies in public sector driven infrastructure , resurrecting the spirit of self-help would be key to renewal of the country.

7. Conclusion and Recommendations

7.1. Conclusion

This study assessed the state, impact, and sustainability of the Gia dam constructed under the Government's Special Initiative project-1V1D. The community members expressed their displeasure at lapses they observed after the construction. Usually, the construction of community water systems requires wider consultations and involvement of local level actors and beneficiary communities, right from the conceptualization to the construction phase. Unfortunately, this was not the case for the Gia dam. The community members and other relevant stakeholders such as MoFA and MDA'S were not involved. Hence, community members as well as technocrats believe that the pro ject is shoddily executed because their views were not taken and there was no proper supervision during the execution of the pro ject . Notwithstanding , the community members see the dugout as a temporal water source livestock watering point. At the same time major lapses were identified that needs swift attention. They include;

- Un-engineered embankment without bolder linings to protect the inner phase of the dam wall.
- Very shallow reservoir area exposing the little water stored to evaporation losses.

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

7.2. Recommendations

The lapses realized after the construction of the Gia dam just like other dams constructed under the 1V1D project limits their potentials for boosting agricultural production and transforming rural economies. Specifically, the dam walls are not engineered, and the reservoir area is not deep enough, hence vulnerable to evaporation. Therefore, it is recommended that;

- The embankment should be reengineered to improve water storage while ensuring the sustainability of the reservoir.
- Rock boulders should 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.
- The portions of the impounded area should be dug to the level of the highest depth creating a gentle slope to create room for more storage while making it friendly for livestock watering. This can be done using the Labour-Intensive Public Works approach to uniformly increase the depth of the reservoir.
- The views of indigenous community members should always be considered from the planning through to the implementation stage.

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