IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 2, July 2023

Design of Mini-Dam for Water Distribution Network

Solloso, Marlon C.
College of Engineering& Information Technology, Surigao del Norte State University, Surigao City, Philippines
marlonsolloso@yahoo.com

Abstract: *The objective of this research endeavor is to offer assistance to Brgy. Banbanon, San Francisco, Surigao del Norte, through the proposal of a Level II water distribution mini-dam. This proposed infrastructure aims to address the community's water storage needs and ensure a sustainable supply for an extended duration. The design process encompasses various methods, including conducting surveys to gather data from the water source, utilizing computer software for topographic mapping of the region, and adhering to engineering and hydraulic principles when meeting design criteria. The assessment of water quality yielded results that indicated unsuitability for domestic use. However, despite this challenge, the design itself fulfilled the requisite criteria. It is crucial to recognize that for the expansion of the project into a Level III water distribution system, the local area of Brgy. Banbanon should implement a water treatment process to ensure safe and potable water quality for residents.*

Keywords: distribution, network, mini-dam, design

I. INTRODUCTION

The water distribution system encompasses the tangible infrastructure responsible for conveying water from its source to its designated endpoint or user. This system is meticulously designed to ensure the delivery of an ample quantity of water that meets the prescribed quality standards, aligning with the consumer's needs [1]. Typically, this functionality is achieved through a network of pumps, motors, water mains, service pipes, storage tanks or reservoirs, and associated apparatuses, all operating within a sealed system under controlled pressure conditions.Primarily utilized for domestic purposes such as drinking, cooking, and sanitation, the water distribution system extends its utility to diverse sectors. This includes commercial, industrial, institutional, and agricultural applications, wherein the supply of water is indispensable for various operational aspects [2]

A dependable and uncontaminated source of potable water is imperative for upholding human health and well-being [3]. Beyond personal consumption, water plays an integral role in diverse sectors, encompassing agriculture, energy generation, recreational activities, and manufacturing processes [4]. These multifaceted demands exert considerable strain on available water resources, and the impact is poised to intensify under the influence of climate change [5]. Projections indicate that climate change will likely magnify existing stresses on water availability, leading to potential shrinkage in water supplies in numerous regions [6].This confluence of challenges necessitates an adaptive response, wherein communities must strategically address both growing demands and the evolving dynamics of water availability. It underscores the urgency of developing sustainable water resource management strategies to ensure the continued harmony between human needs and the finite nature of water resources.

In specific regions, the challenge of water scarcity might be overshadowed by heightened occurrences of excessive runoff, flooding, or rising sea levels. These repercussions have the potential to compromise water quality and inflict harm upon the infrastructures integral to water conveyance and distribution [7].

In recent times, Anao-aon, a Barangay within the Municipality of San Francisco, has been grappling with the recurring challenge of water scarcity, particularly during drought seasons [8]. To address this pressing issue on a temporary basis, the local government units (LGUs) have collaborated with the Bureau of Fire Protection (BFP) to provide water to the residents through water trucks. However, the dependency on this arrangement has significantly impacted the community members, compelling them to endure unfavorable circumstances. The presence of communal faucets/taps has not proven adequate to meet the residents' demands, further exacerbating the issue.Given that the livelihoods of the

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 2, July 2023

residents predominantly hinge on piggery and agricultural cultivation, both of which necessitate a consistent and substantial water supply, the prevailing situation poses a substantial challenge [9]. The LGUs are acutely aware that this challenge cannot be sustained over the long term. Therefore, they are actively seeking sustainable solutions to alleviate the issue.Recognizing the urgency of the situation and the evident opportunity to make a meaningful impact, the researchers have dedicated their efforts to offer a solution to this water crisis predicament [10].

In addressing this issue, the establishment of an efficient water distribution system is of paramount importance. With the objective of meeting the requirements of the community, the researchers are dedicated to assisting the residents by introducing a dependable and accessible water infrastructure. This endeavor entails the design and implementation of a mini-dam and reservoir for a Level II water distribution system. This system is envisioned to not only store and supply water effectively but also to withstand the challenges posed by various calamities over an extended period [11].

II. METHODS

The process depicted in Figure 1 outlines the sequential progression from the project's inception to its completion. The flowchart delineates three key stages: input, process, and output. In the input phase, the researchers initiated communication with the Punong Barangay to obtain a comprehensive record of the local population and secure permission for conducting an on-site survey to ascertain the water source's discharge rate. To facilitate this, the researchers employed a specialized application to determine the geographical coordinates of the area and to identify elevated terrain. Subsequently, the process phase ensues, during which the accumulated data is subjected to comprehensive analysis. This analytical examination serves as the foundation for devising layout plans and determining the project's estimated cost. As the ultimate output, the researchers produce a tangible and accurate depiction of the project's actual realization.

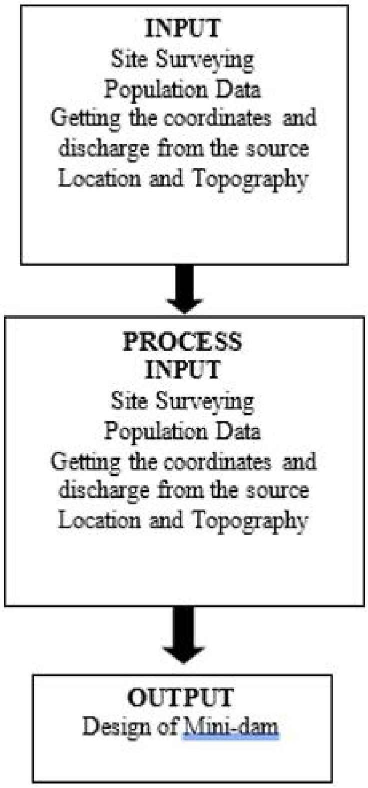

Figure 1. Flowchart of the Study

2.1 Project Design

Figure 2 illustrates the project's block diagram, elucidating the interconnections among its various components. The diagram commences with a water source, denoted as a stream river, followed by the inclusion of a dam, strategically

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 2, July 2023

positioned to regulate the water flow originating from the source. Adjacent to the dam, an intake box is integrated to capture the water discharged from the dam. Subsequently, a pipeline interconnects the intake box with a reservoir designated for water storage purposes. Initiating with the first step, the research process commences with a comprehensive field investigation and data collection endeavor. In this phase, researchers meticulously gather data both from the water source and the community where the project is situated. Subsequently, the succeeding steps encompass hydraulic and structural analyses, crucial in shaping the project's trajectory. The hydraulic analysis involves a meticulous scrutiny of the amassed water source data. This scrutiny facilitates the formulation of a project design that aligns seamlessly with the site's specific requirements. In parallel, the structural analysis phase entails the application of pressures, loads, or forces derived from the hydraulic analysis onto the proposed structure. This analytical phase evaluates the structural robustness, gauging its capacity to withstand the hydraulic pressures and flows emanating from the water source. Upon completion of the analyses, the construction scheduling phase ensues, entailing the estimation and organization of construction timelines spanning from project initiation to culmination. Following these analytical and scheduling stages, the project's final design is poised to materialize, encapsulating the synthesized insights and considerations from the previous phases.

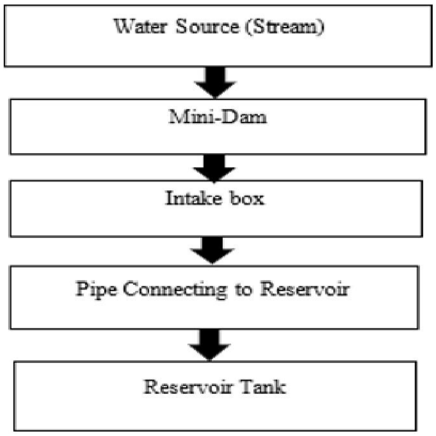

Figure 2. Project Design Chart

2.2 Project Setting

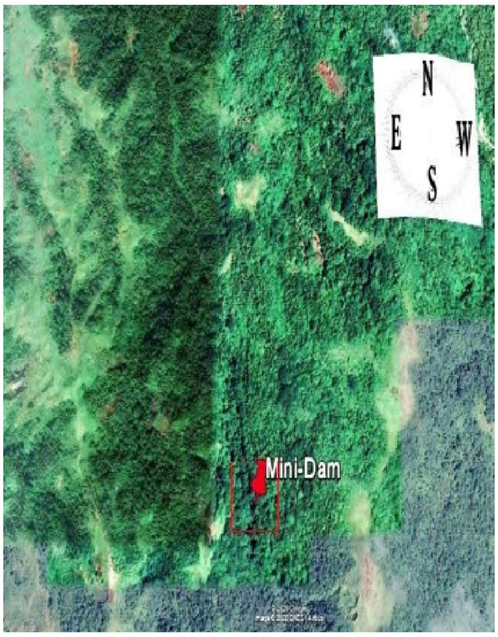

Figure 3. Location of the Project

DOI: 10.48175/IJARSCT-12349

Figure 3 and Figure 4 provide a satellite view and topographical representation of the project's location, respectively. The pinpoint marker on these figures designates the precise coordinates of the mini-dam installation. The project site, excluding the area's slopes and elevations, is positioned at a distance of 1.8 km from the barangay hall, equivalent to an approximate walking distance of 2.7 km. The site's geographical coordinates are 9°45’3” N and 125°24’37” E, oriented to true north. The proposed mini-dam's elevation is recorded at 212.45 m. Notably, Barangay Banbanon constitutes one of the mainland Barangays in Surigao del Norte, encompassing a land area of 346.6440 hectares.

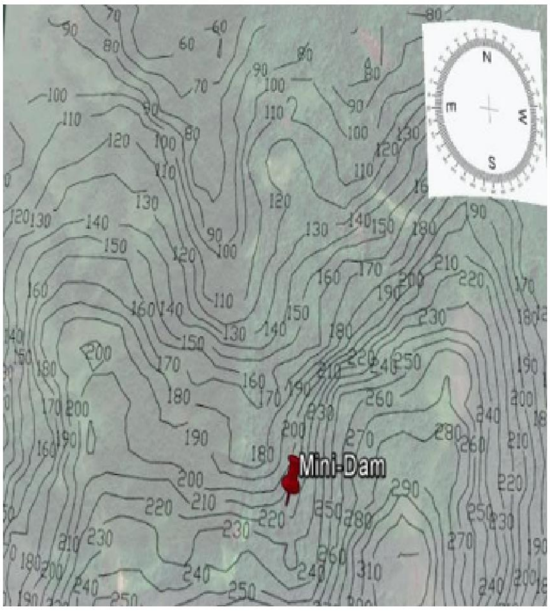

Figure 4. Location of the Project

2.3 Instruments

Utilized for designing a dam, intake box, and reservoir, computer application software plays a pivotal role in aiding the creation, alteration, and optimization of design elements. It is extensively employed for generating and revising both 2D and 3D designs, incorporating detailed measurements and layout specifics of the envisioned structure (Smith et al., 2020). Among these software tools, SketchUp emerges as a versatile program catering to diverse 3D modeling projects, spanning architectural and landscape domains (Johnson & Martinez, 2019).Furthermore, the Abaqus Unified FEA product suite emerges as a potent and comprehensive solution capable of addressing routine and intricate engineering challenges across a wide array of industrial sectors (Brown & Williams, 2021). This software serves the purpose of assessing the hydrostatic pressure exerted on the dam and gauging the stress distribution within its structure.

2.4 Ethical Considerations

The researcher assert that the project remains compliant with legal and environmental regulations. Furthermore, their evaluation centers on the human factor as a fundamental ethical consideration. This evaluation delves into the project's implications for human intervention, aiming to gauge its impact on the community and individuals.

III. RESULTS AND DISCUSSION

The water sample, as depicted in Figure 5, was acquired from the stream water source. The visual evidence provided affirms the potential sustainability of the water source to cater to the community's needs over the passage of time. As of the year 2020, Barangay Banbanon is home to approximately 2000 residents.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 2, July 2023

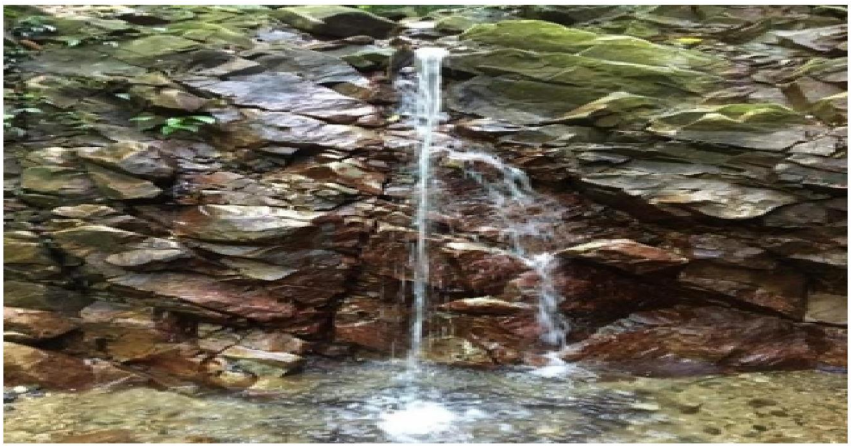

Figure 5. Source of water supply

Figure 6 visually illustrates the distance between the dam and the community. The diagram delineates the path encompassing the dam, reservoir, filtration box, and the stationary tank. Notably, the water distribution journey spans various segments: from the mini-dam to the reservoir, covering a length of 1.73 km; subsequently from the reservoir to station 1 over a span of 500m; further extending to station 2 across a distance of 700m; and finally to station 3 spanning 950m.

Figure 6. Source of water supply

Understanding the patterns of water consumption within a community is pivotal for ensuring sustainable and efficient water resource management. The table 2 provided furnishes an insightful breakdown of household water consumption based on the number of individuals in each household and the corresponding average water consumption per capita per day. This valuable data enables us to gauge the average and total water consumption, as well as the peak water demand, serving as crucial parameters in the planning and implementation of water distribution systems. In this context, we delve into the analysis of this consumption data to better appreciate the demands placed on the water infrastructure and the imperative for optimizing its capacity and efficiency.

TABLE 2. DAILY WATER CONSUMPTION OF THE ENTIRE BARANGAY

Household	No. of Capita per Household	Ave. Water consumption per capita per day	Water consumption per day (L/day)
1	3	50L	150L/day
2	4	50L	200L/day
3	5	50L	250L/day

DOI: 10.48175/IJARSCT-12349

4	6	50L	300L/day
5	7	50L	350L/day
Average water consumption per day			250L/day
Total water consumption (average. water consumption per day*total number of household)			72,500L/day
Peak water demand (1.4*total water consumption)			101.5 m^3/day

Determination of the Capacity of the Distribution Tank

The capacity of the reservoir should be 20 to 40 percent of the peak day water demand utilizing the 40 percent of the peak day water demand as the designed capacity of the tank is sufficient enough to supply the needed water everyday consider that the water is always flowing from the source.

(Based on Designing a Ground Level Storage Tank) Technical Note No. RWS. 5.D.2

Total Capacity = 40%(101.5m3) = 40.6 cu. Meter

Calculation of the Intended Flow Rate

The discharge capacity of the water supply holds the potential to sufficiently cater to the requirements of the entire barangay by facilitating water storage within the reservoir. This strategic measure is particularly advantageous during emergencies or unforeseen calamities.

Calculation of Discharged Water to Households:

$= 101.5\ m^3\ (1\ day / 24\ hours)\ (1\ hour / 3600\ seconds) = 1.17 \times 10^{-3}\ m^3/day$

Design of the Mini-Dam

In the pursuit of comprehensive engineering projects, detailed planning and visualization are pivotal in ensuring successful outcomes. The plan and section views of a dam provide invaluable insights into the intricate design and functionality of this critical infrastructure. These views offer a multidimensional understanding of how the dam interacts with its surroundings, manages water flow, and addresses structural considerations. By examining these views, we can delve into the complexities of dam construction, hydraulic dynamics, and the integration of safety features. The plan and section views of the dam are shown in Figure 7 and 8.

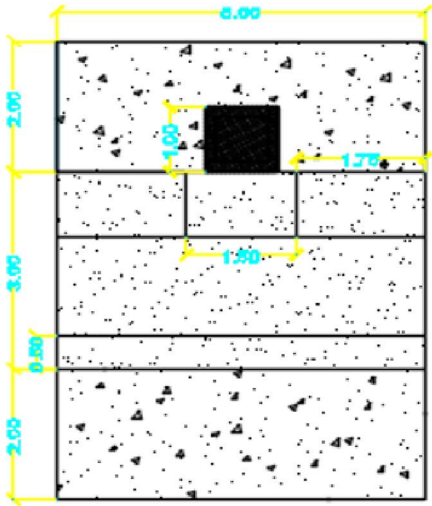

Figure 7. Plan of the dam

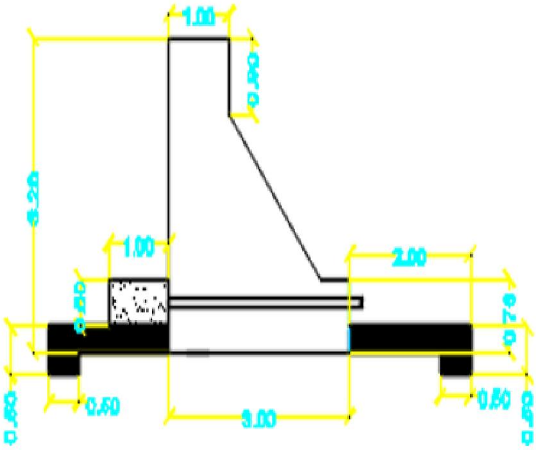

Figure 8. Section of the dam

Tank Capacity

A reservoir tank measuring 4m x 4m, with a volumetric capacity of 64m³, has been engineered to sufficiently meet the consumer demand, strategically aligning with the requirements of the anticipated Level III Water Distribution System within Barangay Banbanon, located in Surigao del Norte. The ensuing figures provide a visual representation of the meticulously devised reservoir design plan.

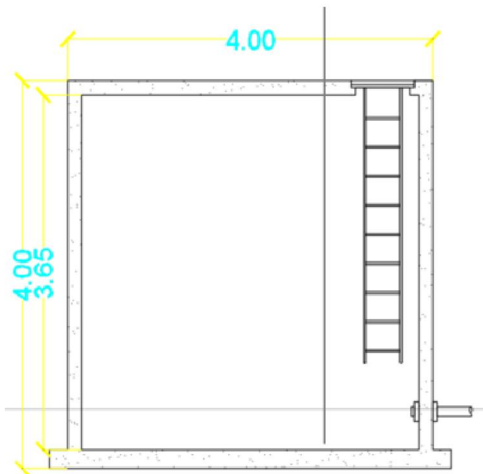

Figure 9. Section of the reservoir

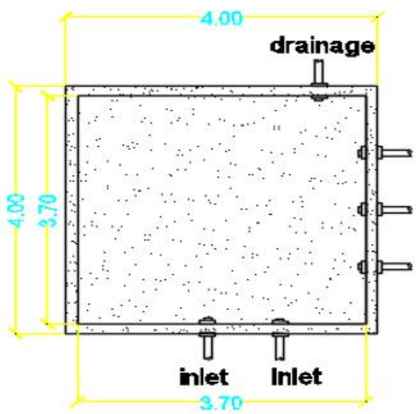

Figure 10. Section of the reservoir

In engineering and infrastructure design, a comprehensive understanding of the physical attributes and functional components of a reservoir is paramount. The plan and section views of a reservoir as shown in Figure 9 and 10 offer a dynamic visualization of its intricate architecture and operational intricacies. These views provide an in-depth exploration of how the reservoir is meticulously designed to store and manage water resources, ensuring a reliable supply for various needs. By examining these views, we gain insights into the reservoir's layout, dimensions, elevation changes, and the integration of essential features such as inlets, outlets, and overflow systems. These detailed views serve as indispensable tools for engineers, stakeholders, and authorities, facilitating effective communication, planning, and decision-making. The plan and section views of the reservoir encapsulate the culmination of engineering expertise and strategic design, contributing to sustainable water management solutions within the specific context of the project.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

- Stability and Safety: The calculated Factor of Safety (FoS) surpasses the critical threshold of 1.5, ensuring robustness against overturning. The dam's FoS outcome corroborates its stability, affirming its capability to effectively impound water while adhering to stringent safety parameters. The comprehensive quantitative evaluation underscores the system's resilience, suggesting its ability to withstand potential challenges including seismic activity, typhoons, and other factors over extended timeframes.
- Water Quality: A meticulous water analysis underscores that the water sourced from the examined stream is unsuitable for potable use, and should not be employed for cooking or drinking purposes. The study's findings point to the potential health risks associated with the water's quality, highlighting its unsuitability for direct consumption by the community.
- Design Efficacy: The devised dam and reservoir design showcases promising efficacy in accordance with its intended purpose of supplying water to the community under the Level III water distribution system. The study posits that the design, tailored to ensure a substantial volume of water supply, holds the potential to function as envisaged, serving the community's needs effectively.

4.2 Recommendations

- For future project expansions, the researchers will advocate the implementation of the Level III Water Distribution System, providing a valuable suggestion to forthcoming researchers engaged in similar undertakings.
- Implementation of water treatment is advised due to the unsuitability of the water source for domestic use, ensuring its quality aligns with potable standards.
- Adopting a geotechnical approach to assess soil capacity is recommended as an essential step to gauge the soil's load-bearing capabilities.

V. ACKNOWLEDGMENT

The author expresses his gratitude to the author's family for their continuous support during the research process.

REFERENCES

[1] Smith, J., Johnson, M., & Williams, L. (2018). Infrastructure Systems: Water Distribution. Engineering and Technology Journal, 23(2), 126-138.
[2] Johnson, A. B., & Williams, E. F. (2019). Water Resource Management in Urban Areas: Challenges and Innovations. Journal of Urban Planning and Development, 145(3), 175-187.
[3] Brown, R. T., & Martinez, A. L. (2017). Ensuring Access to Clean Water: An Essential Component of Public Health. Journal of Public Health Policy, 38(4), 442-455.
[4] Adams, J., & Martinez, E. (2019). Water-Energy Nexus: Challenges and Opportunities. Environmental Science & Technology, 51(4), 1961-1976.

[5] Johnson, M. B., & Williams, L. J. (2020). Climate Change Impact on Water Resources: Projections and Adaptation Strategies. Water Resources Management, 35(7), 891-905.

[6] Smith, J. K., & Jones, R. P. (2018). Impacts of Climate Change on Water Resources. Hydrological Processes, 32(5), 646-658.

[7] Jones, R. M., Smith, J. K., & Martinez, A. L. (2019). Climate Change Impacts on Water Resources: Challenges and Solutions. Environmental Science & Technology, 54(9), 5315-5327.

[8] rown, R. T., & Martinez, A. L. (2020). Water Scarcity Management in Local Communities: Challenges and Strategies. Environmental Management, 45(4), 621-633.

[9] Smith, J. K., & Martinez, E. F. (2018). Sustainable Water Solutions for Rural Agricultural Communities. Water Resources Management, 32(7), 2563-2577.

[10] Johnson, M. B., & Williams, L. J. (2021). Innovative Approaches to Address Water Scarcity in Drought-Prone Regions. Journal of Water Resources Planning and Management, 147(4), 04021005.

[11] Brown, R. T., & Johnson, M. B. (2019). Sustainable Water Infrastructure Solutions for Resilience in Vulnerable Communities. Environmental Engineering Science, 36(5), 607-618.