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Exploration Involving the Community in Upgrading Water Intake in Kampung Bongol, Tamparuli, Sabah, Malaysia

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Abstract: This research focuses on an important project to upgrade the water supply system for a rural area in Kampung Bongol, Tamparuli, Sabah, Malaysia, with exceptional involvement of the communities. This village is located approximately 60 km away from Kota Kinabalu town center, and the journey takes around two hours by car. Despite its remote location and the challenging geographical surroundings of mountains, the village is conveniently situated near an existing catchment area. However, this village's current water distribution setup relies on outdated and inadequate tools, systems, and facilities, leading to water scarcity issues, particularly during drought periods. To address this problem effectively, a sustainable design consisting of a mini dam and a ramp pump was developed and implemented in this study. Combining these two elements ensures the rapid filling of the storage distribution tank and the provision of clean water to the residents. One noteworthy feature of this project is the utilization of a 2-inch Polyvinyl chloride (PVC) ramp pump, significantly reducing operational costs and eliminating the need for fossil fuels. This design not only proves to be practical and sustainable but also encourages the active participation of the villagers. Despite financial constraints and technical challenges associated with the project's implementation in a remote location, the water upgrading initiative was completed within four months, thanks to the direct involvement of the community. As a result of this endeavour, a fully functional water distribution network using the newly designed system has been installed, ensuring a reliable water supply for the 200 villagers in Kampung Bongol.

Keywords: Sustainable water supply, ramp pump, rural area, mini dam, community participation

1. Introduction

The water crisis has become a global issue; however, the main cause of it is not a lack of water but inadequate resource management. The deterioration of water quality due to development, unmatched water supply, lack of effective river basin and improper facilities to extract and supply water are examples of improper water management, which can drag into the water crisis [1]. In Malaysia, rivers are vital for nature and human society. Major cities have been established and flourished along rivers. Rivers are rich ecosystems and sources of life, providing water supply, irrigation for agriculture, a means of transportation, a source of food in fisheries, hydroelectric power, and water use for industries [2]. Malaysia is also covered with large rainfall catchment areas, especially in southeast Malaysia, Sabah and Sarawak. According to Roslee & Tongkul [3], the average rainfall in Tamparuli, Sabah is around 7.8 mm/h to 42.2 mm/h, which is high and enriches that area with water surface resources. However, most rural residents still lack proper water access and struggle to get clean water for their daily uses [4]. Karunakaran et al. [5] stated that the percentage of

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piped water in rural areas of Peninsular Malaysia is 96%, while Sabah and Sarawak lagged with only 16% in 2020. The main factors of this issue are challenging topography (mountain area) which caused the installation of expensive infrastructure, and rural areas are broad compared to the urban ones, which make the developed facilities less noticeable. Moreover, the rural population's scattered is another factor that makes development difficult. Based on the literature review and facts, it can be summarised as the water crisis in Sabah and Sarawak is affected by improper management and facilities, and not because of lack of water resources.

The hydraulic ram pump, also known as a hydram, is a fully automatic device that exploits the kinetic energy in flowing water, such as a spring, stream, or river, and uses the pressure that occurs in the system to pump a portion of the water to a height above the source [6]. A hydram is a structurally simple unit consisting of two moving parts: the impulse valve (or waste valve) and the delivery (check) valve. The unit also includes an air chamber and valve. The activity of a hydram is intermittent because of the cyclic opening and clone of the waste as well as delivery values. When the waste valve is closed, the pressure in the drive line rises significantly. Therefore, an air chamber is necessary to convert the high intermittent pumping flows into a continuous stream of flow. Because of the high pressure and mixing in the air chamber, the air valves enable air into the hydram to replace the air absorbed by the water. One of the advantages of a hydraulic ram pump is operated without any fuel or electricity, which makes this technology sustainable and environmentally friendly. Moreover, the zero-emission fuel property of this pump has made it cheap and widely used worldwide, especially in rural areas. However, this method is less popular in Malaysia.

Kampung Bongol is a village located in Tamparuli, Sabah, and this village is 58.1km from the University Malaysia Sabah (UMS), which takes about 2 hours to drive. It is also one of the affected villages to get daily clean water supply despite being in the rainfall catchment area. However, the lack of facilities to extract and supply water from nearby water resources causes the villagers to experience water shortages every day. Due to that, a collaboration project of upgrading water supply system between members of parliament Tuaran, Kampung Bongol residents' and institutional organizations (Universiti Malaysia Sabah and Politeknik, Kota Kinabalu) has been done to overcome this problem. Prior, the villagers depended on traditional water intake systems and rainfall harvesting methods, as depicted in Fig. 1. As seen, the insufficient method of rainfall harvesting will risk the residents with various diseases and inadequate water supply, especially during drought season (February and March).

Traditional pipelines to extract water from water resource.

Water from the pipelines will be collected here before distribute to the villagers by gravity flow.

Most of resident houses in this village installed improper rainfall harvesting system to collect water as their daily use

Fig. 1 - The existing water collection system in Kampung Bongol, Sabah

This project aims to design and construct new sustainable water intake in Kampung Bongol and reduce the gap of essential facilities to rural communities. In this project, a new weir, hydraulic ram pump and intake system have been designed and built to replace the old water system, which makes it more effective and systematic. Additionally, replacing conventional electric or fuel pump with ram pump has benefited the residents as they are not required to pay water and electricity/fuel bills. Also, this project can be an example for future water intake systems in extreme topography and rural areas.

2. Project Profile

The location of the study area, Batu 17, Kampung Bongol, Tamparuli, Sabah which coordinate 6.100930, 116.422414 is depicted in Fig. 2. Kampung Bongol is a small village located on the east side of the Tuaran district. The water resource is mainly from mountain runoff or subsurface storage, which has been used for agricultural or nonpotable for many years. The total population in this village is estimated as 200 villagers and 42 houses. The upgradation of the water intake system and installation of water tanks will improve the water supply in Kampung Bongol, especially the houses located at Batu 16, Simpang Kota Belud, Batu 17, and Jalan Mantaranau areas. The Batu 14, Lokos, and several parts of Batu 16 areas will be excepted from the distribution of water supply project as they have received water supply from the Kalasasan water resource system. This project's execution will focus on improving water intake, including constructing the water intake weir until central storage and distribution tanks. Based on Fig. 2, the vicinity of the water intake system is in the upstream area, and water will be distributed to the residential area by two systems: gravity flow for the downstream area and a ramp pump system (to lift the water to the high zone). The project workflow is depicted in Fig. 3. This project started with sampling and water quality checked, followed by water intake and storage station design, construction work and final system trial as the project completion. The village/community representative was involved since the beginning with series of discussion, sponsor meetings (Parlimen Tuaran), site visits, water sampling, design discussion and improvement up to construction work and completion.

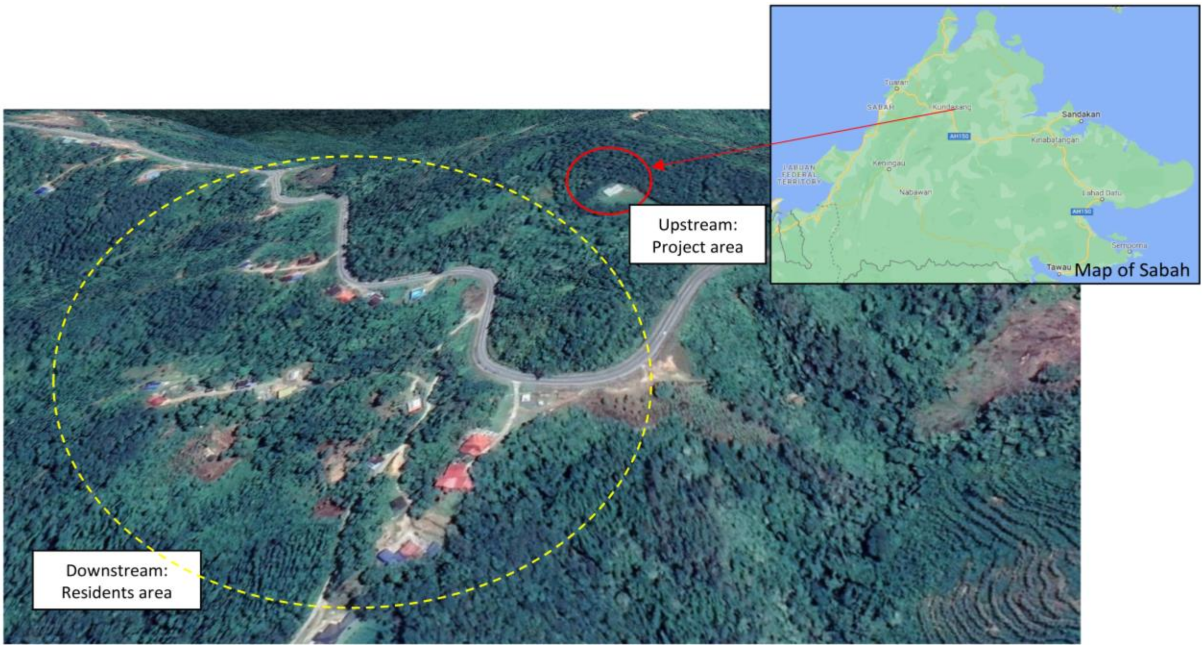


Fig. 2 - Location of the community project

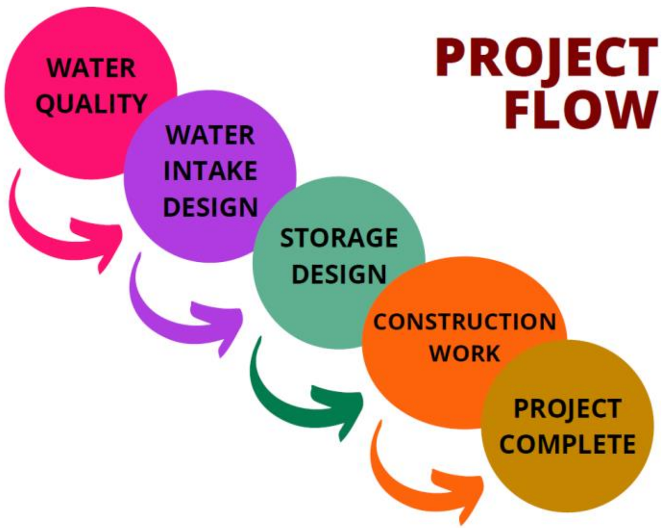


Fig. 3 - The project workflow incorporated engineering final year students and the community

3. Water Quality Condition

The samples were collected from the old water system as depicts in Fig. 4. The in-situ test was done for parameters pH, temperature, conductivity and Total Dissolved Solid (TDS while other parameters were tested in the Environmental

Laboratory, Faculty of Engineering, UMS. The sample collection and preservation procedure were performed by following the Standard Methods for the Examination of Water and Wastewater, 2017 [7]. In addition, analysis of water characteristics such as turbidity (Method 8038), Biological Oxygen Demand (BOD_5) (method 5210B) and Chemical Oxygen Demand (COD) (SM) 5220 D were also conducted by following the Standard Methods for the Examination of Water and Wastewater, 2017 [7]. The result of water quality is presented in Table 1.

Fig. 4 - Sampling and water quality test of water resource at Kampung Bongol, Tamparuli, Sabah

As seen in Table 1, most parameters are recorded as good quality with low pollutant concentration, except for BOD_5 which is slightly over the standard of Class I. The pH of water sample from Kg. Bongol recorded as 7 which is safe to be used based on the standard limitation NQWS. The second tested parameter is turbidity and the data recorded as 1 NTU which is also below the standard limitation (5 NTU). Based on the observation, the fountain in this area is well preserved from any social and development activities, therefore, sediments or suspended materials such as mud, water algae, small animal species which can be reasons of turbidity are less presented here [8]. In short, low amount of turbidity value indicated that less amount of unwanted elements in water, and so water in this area is suitable to be used as daily usage.

The next tested parameter is Total Dissolved Solid (TDS) and the concentration recorded is 20 mg/L which also falls under the standard requirement by NWQS (Table 1). Total dissolved solid is related with the water resource and according to Kent & Belitz [9], water characteristics from mountain sites can be categorized into two groups; the alpine indicator (high watershed area) and ionic characteristic which is located at the valley area (low area). Water resource in high area (alpha indicator) is characterised as low TDS due to the high intensity of rainfall which will dilute the stream TDS concentration. In this project, the existing water resource can be categorised as high watershed area and the value of TDS recorded is in the line with the previous researcher’s statement. Also, the total suspended solid is recorded as low (6 mg/L) and below the standard limitation (Table 1).

Table 1 - Summary of water quality at Kampung Bongol

No.	Parameter	Unit	Concentration	Class I NWQS*
1	pH	-	7	6.5-8.5
2	Temperature		24.80	-
3	TDS	mg/L	20	500
4	Turbidity	NTU	1	5
5	TSS	mg/L	6	25
6	COD	mg/L	4	10
7	BOD_5	mg/L	1.5	1

*National Water Quality Standards for Malaysia [10].

Another important parameter tested in this study is Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD_5). According to Zakaria et al. [11], COD concentration reflects the level of pollution in the sample and as seen in Table 1, COD recorded only 6 mg/L which is under the range of Class I of NWQS. Whilst the concentration of BOD_5 is slightly higher compared to the standard (Class I). Class I referred to the water quality which is suitable for very sensitive aquatic specifies and daily water supply [10]. This type of water does not practically require any treatments. The data obtained also has strengthen the statement of water resource in this area is clean, safe for daily uses and can be classified as in class I. The detail design and construction of water intake and storage at Kampung Bongol will be discussed in the next section.

4. Water Intake System Design and Construction Works

The main objective of this study is to improve the old water intake and collection system in Kampung Bongol, therefore, in this project, two stations (water intake station and storage station) were designed and constructed at the same location of old station. The installation and construction of water intake and storage station in this area were successfully done in three months (October 2021 until January 2022). In the water intake station, several new components were installed such as mini dam, new High-Density Polyethylene (HDPE) and Polyethylene (PE) pipeline, PE storage tank, ramp pump and concrete slab. The plan of the project is depicted in Fig. 5. Prior to the construction work, the site clearing was done together with the villagers.

Based on the measurement on site, the water flowrate in existing water intake is around 0.1 m^3/s and the volume of it tends to reduce especially during the dry season. This condition potentially affects the functionalities of ramp pump as well as disruption of water supply to the population especially during drought season. Therefore, a mini clay brick dam or weir with dimensions of 5 m width and 0.45 m high was proposed and built in this project as a water reservoir (Fig. 5). The dimensions of the dam/ weir were designed according to the existing size of fountain on site. Then, the water flows to the Polyethylene (PE) cylindrical tank 1800 L (collection tank/ header tank as in Fig. 6) using 1-inch of HDPE drive pipe before entering the ramp pump and pump up to the PE cylindrical tank 10,000 L. The discharged water from the pump will be flowed to the second PE cylindrical tank 10,000 L (Station C) which located at the bottom of ramp pump station. A header tank is important to provide continuous large amount of water flow into the pump since ramp pump uses water hammer effect to lift the water to a higher height [12].

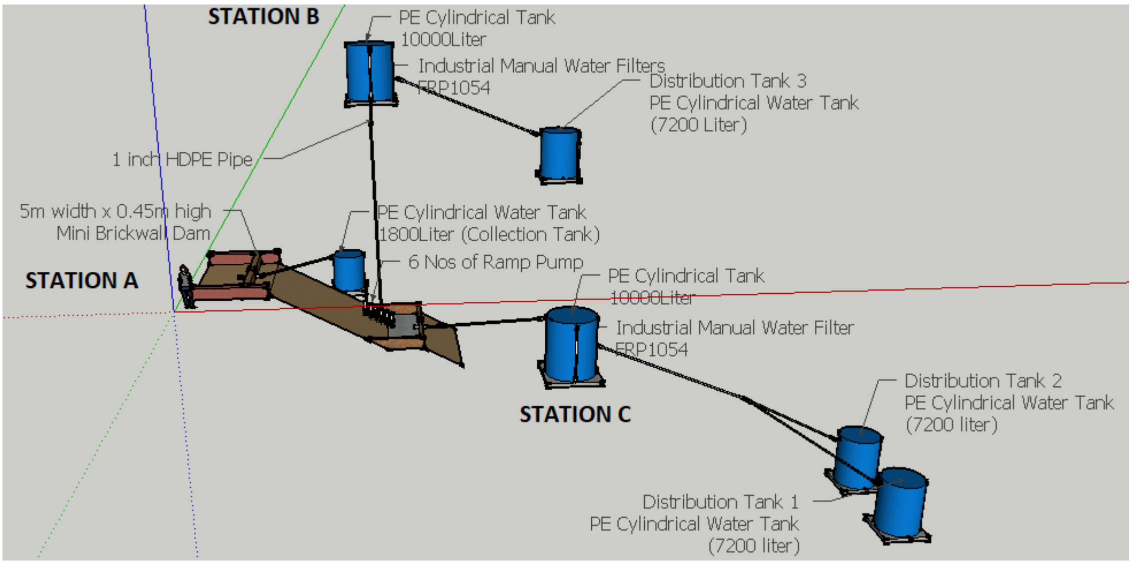


Fig. 5 - Overall design of water intake project at Kampung Bongol

Fig. 6 - Construction of collection/ header tank station at water intake station

In this project, 1-inch of drive pipe was connected and flowed the water from header tank to the ram pump. The drive pipe functions as supplying the water to the pump body with high velocity and also to resist the shocks of water hammer effect. Notes, the less ramp pump system absorbs the shock, the more effective the pump functions [13]. Initially, 6 units of 2-inch PVC ramp pump were proposed and designed as parallel in this project, however, the number of ram pump was reduced to 3 units since the capacity of pump to lift the water (delivery flow) is measured as 2 L/min and it is capable to fill the tanks in according time.

Notes, this design is only suitable for the site which has the elevation of ramp pump station and storage station less than 100 m [13]. The elevation of water intake (ramp pump station) and storage system in this project is only 10 m and suitable to follow the design. Therefore, 3 units of ramp pump with 1 additional unit (a maintenance pump) as depicted in Fig. 7 were installed on site. The water pumped from the ramp pump was delivered to the distribution tank using 1-inch of HDPE delivery pipe. The design of ramp pump has followed the design of [13], with some modifications according to the actual on-site condition.

Fig. 7 - Ramp pump used in this project

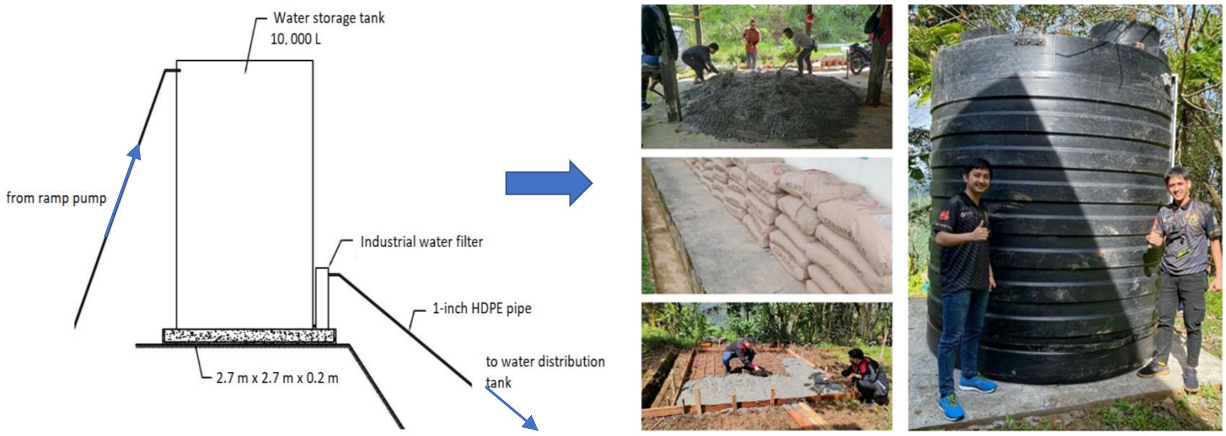
Subsequently, the remaining water which discharged from the ramp pump was transferred to the PE distribution tank (7200 L) located at the bottom area. As known, ramp pump is only effective to lift 20% - 40% of water and the remaining of it will be discharged from the system. Therefore, the discharged water will be collected in the PE cylindrical tank (10,000 L) before it flows to the distribution tanks which are located at the bottom area and distribute to the residents' houses (downstream area). Thus, water will not be wasted in this design. Additionally, this water intake design considers the number of houses in the area (42 houses) and the number of residents in the village (200 villagers).

5. Water Storage Design and Construction Work

The second phase of construction work in this project is a water storage and distribution station in Station B and Station C. The distance between Station A and Station B is 10 m. The water storage is a second water collection tank after the header tank station. In order to meet the total water demand of the residents which is 40, 200 L/day, two 10, 000 L of PE water storage tank and three 7200L PE distribution tank at station B and C were installed together with water filter facilities (industrial water filter) (Fig. 5). The number of tanks and sufficient storage capacity is very important in water supply system in order to prevent the water shortage problem. The calculation of the total water demand is as follow:

- Average water demand in Malaysia (Air Selangor, 2021) = 201 L/capita/day
- Number of residents = 200
- Total water demand at Kampung Bongol, 201 x 200 = 40, 200 L/day

Water stored in Station B is functional to supply water for the residents at hill area. It is located at the high ground level while Station C distributes to the residents at downhill area by gravity flow. A concrete foundation of the storage tank (10, 000 L) was constructed with dimension of 2.7m width, 2.7 m length and 0.2m depth to support the total weight and size of the tank as depicts in Fig. 8. As seen in Fig. 8, the concrete foundation was constructed using welded steel fabric reinforcement of 200 mm x 200 mm mesh weighing 3.95kg/ms, cement, sand and aggregate. Similar with water intake in station A, the water will be flowed from one point to another by 1-inch HDPE pipe. After completing the construction and installation, the trial of the system was done to test and detect any deflection or error. As a result, the system happened to function well. The built brick dam is able to function as reservoir and provide continuous water to the header tank which makes 2-inch ramp pump works effectively. In short, the combination of this system has worked efficiently and improved the social economic life of the residents.



Design Layout for Storage Tank (Station B)

During and After The Construction Work

Fig. 8 - The design and construction work for concrete slab and installation of water storage tank at Station B and Station C

Additionally, this project is carried out with allocations used from the member of parliament Tuaran, Sabah. The cost of this project is calculated as 6320 USD and the details distribution of the materials expenses are presented in Table 2. All the materials were purchased from the local supplier. The cost covered the prices of materials while the labour work was done together with the stakeholders.

Table 2 - Summary distribution of material costing for this project

No	Items	Quantity	Percentage distribution of the material cost (%)
1.	PE Cylindrical Water Tank (10000L)	2 units	34
2.	PE Cylindrical Water Tank (1800L)	1 unit	1
3.	PE Cylindrical Water Tank (7200L)	3 units	24
4.	1" HDPE Pipe (100m/bundle)	21 units	14
5.	Industrial Water Filter Manual FRP1054	2 units	9
6.	Ramp pump	4 units	4
7.	Clay Brick for Intake Damp	1 kg	1.2
8.	Cement	40 kg	2.6
9.	Sand	4 kg	1
10.	Aggregate	6 kg	1.9
11.	Welded steel fabric reinforcement of 200mm x 200mm mesh weighing 3.95kg/ms	5 units	0.3
12.	Miscellaneous (safety, construction materials, emergencies etc)	-	7

6. Conclusion

The project was successfully executed, and the community played a direct role during discussions and making-decision on the design and construction implementation throughout the project. This project materials and construction, valued at USD6320, provided the immediate water need for the 200 people of Kampung Bongol. The installation and construction of the water intake and storage station in this area were done using a ramp pump to replace the fuel pump. It has reduced the operational cost and brought the residents to smile when their utility of water bill is cheaper than before. Installing a pipeline and storage system to replace the traditional/ bamboo pipelines has provided the residents with a continuous supply of clean water. This project proves that collaborations between universities/ institutions and communities are essential to solve the communities' problems effectively and economically according to the nature of that area. Moreover, this project is also considered an excellent platform for engineering final-year students to experience and practice the knowledge they have learned in the class. Thus, this paper enlightens a guideline to the researcher and academia on introducing and implementing suitable technology to the communities in the future.

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