Implementation of vertical multistage centrifugal pump system for villages at an altitude of ± 1200m above sea level in Sipahutar – North Sumatera area

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Abstract. Clean water supply is rare in most villages at an altitude of ±1200m above the sea level in North Sumatera due to the topography of the village. The idea to help villagers fulfilling their basic needs in the situation makes this research important. Many experiments had been done previously, such as implementing drilled well but none was successful until we developed a vertical multistage centrifugal pump system. The natural water spring in the area targeted was found in 86 meters depth and would be distributed as far as 500m with area of 1.5km² from the water tank. The main problem happened was the electric supplies which was always lower than it was expected in that area. Therefore, the successful of the system was happily accepted by the villagers and this research is highly expected to be developed and implemented to other villages, not only in Sipahutar area but also in all Tarutung area. Keywords: clean water supply, vertical multistage centrifugal pump system, village, North Sumatera, high altitude area.

Introduction
Clean water is a vital needs for human beings [1-5] which can be provided from natural water reservation, artesian well, or supplied by industry. Lumban Lobu, in Tapian Nauli I, Sipahutar district, North Sumatera area is 50km away from Tarutung city. This place has suffered from fresh clean water since long time ago. This village is at an altitude of ±1200m above the sea level where dry plantation can be found along the hill side and no water supplied is available naturally. The topology of village is high up in the hill side while the water reservoir is deep in the valley. The villagers have to depend on the rain for water supply which is kept in the open tank. The rain drops will touch the rusty roof before finally fall down and is kept in the water tank. In this situation, the availability of clean-hygiene water is really rare to the villagers. The water kept in the tank will last within one week. Every house has this open tank just under the edge of the rusty roof and there is no spillway from the tank.

During the dry season, villagers, regardless to their age, have to walk down to the valley for about 0.5 to 1km with the slope of almost 80 degrees and 85m deep in order to get fresh clean water. They will bring buckets or containers to fill in with the fresh water and bring them back on their heads to their village for several times a day. This situation continues from time to time, because this natural water reservoir is the only nearest place to rely on. It takes 15 to 30 minutes for each villager to climb up from the water reservoir to the village and usually due to the stiffness; the water in the container will remain a half when they reach their home.
This village is divided into 5 areas; Sosor, Tungko Rau, Huta Galung, Lumban Sihobuk and is abbreviated to SorGaRauHobuk and Siranggiting. In this village, the public primary school and public house are placed in the middle of the village. The number of family in this village is 80 with their main activities are farming such as coffee, pineapples, and myrrh. Unfortunately, the result of agricultural crops is not enough to help the economics of the villagers. For the past few years, a clean water program has become the main issue to solve and a project had been done previously. In 2003, one of the church organizations tried to supply the water from Siborotan Mountain in 20km the north part of the village. The pipes were connected from the higher altitude water source and directly guided to the open container in the middle of the village. However, the flow of the water became smaller since 2007. Moreover, the people from the north area also blocked the pipe totally so that villagers who live in the south part could not get the water. This situation also made the pipe facility totally broke down and the reparation will be costly compared to building the new one.

The villagers also tried to build an artesian well but this plan was totally failed since it took more than 50 to 70 meters depth to get the fresh water. Still, the budget needed to accomplish this project was too expensive and the villagers had no more fund to do this project. By year 2011, the first water supply project was carried out and done in four phases until 2015. The phases will be explained in detail including the design and implementation. At this moment, we are trying to complete the sixth phase as well.

**Design and Implementation**

In 2011, an idea to help the villagers to get the water was developed. The idea was realized as a pilot project which was built in Electrical Engineering laboratory at University of Pelita Harapan. Later on, together with Computer Engineering Department of Bina Nusantara University, a research road map was designed and implemented in several phases as shown in figure 1.

![Figure 1. Research roadmap.](image-url)

The first phase started from March 2011 to June 2011. In this phase, we found the natural water spring 86 meters below the nearest hill with water flow rate of 4000 liter per hour. The vertical multistage...
centrifugal pump[6-7] system and the supply tank were placed near the water spring as shown in detailed in figure 2. The water spring kept in a water tank before pushed through pipes by using push pump system to the hill side. The pump was put 1 meter lower than the height of water in the tank in order to keep the vacuum condition inside the pump[8]. The water distributed through pipes from hill side and kept in the water tower which was maximum 8 meters lower that the water tank in the hill side. Another piping system was also built to distribute the water from the tower to the nearest concrete water reservoir equipped with tap or valve. Therefore, people could take a shower, wash clothes, and take water for cooking directly to the concrete reservoir which is only few meters from their houses. In this first phase the water supply was distributed to 44 families. The further map to show the exact location of the establishment can be seen in figure 4.

![Diagram](image)

**Figure 2.** The blue print of vertical multistage centrifugal pump where (a) is the whole system and (b) is the electronic system for running the pump.
The vertical multistage centrifugal pump used in this design was CDLF 1-210 CNP[9]. It was a light vertical multistage centrifugal pump driven by a standard electronic motor 1.5 Hp 1 phase 220V. The motor output shaft connected directly to the pump shaft through a coupling. We also used voltage stabilizer 7500Watt in order to feed constant voltage current to the pump as for drop voltage protector[10] was a homemade one based on common protector in market as shown in figure 3, namely voltage comparator[11].

On the second phase, the water distribution system worked out and could supply 1600 liters of water per minute. We found out that electricity was not stable during the first phase installment which broke down the pump. We asked the Tarutung local government to supply the electricity with additional power to the village. Unfortunately, when we measured from the first post to the pump, the drop voltage still severed from 200V to 170V. Therefore, we installed stabilizer in the pump system before finally the whole system really worked out.

By the time the news about this water system spread out, the number of families demanded for water supply increased. On the third phase, we built another water system by lengthening the pipe from Tungko Rau, Sirangginting, Hutagalung to Sosor as seen in figure 4. We also developed a backup system in order to avoid system failure due to drop voltage problem. In this phase, we could supply the water to 80 families. This area has regular lightning strikes every year. Therefore, along 2014, the lightning struck the water supply system more than twice.

In the fourth phase, we focused on building lightning arresters in several spot as well as expanding the amount of water supplied by adding the second vertical multistage centrifugal pump system as shown in figure 2. The number of water tower also increased from one to three water towers. The pump will be working simultaneously and being controlled by analog timer for every 30 minutes. Therefore, the overheating condition which sometimes happened during operation can be avoided. However, the water distribution system has not reached public primary school - the only school in the village and the village community center yet. We have planned do the sixth phase in 2016 and proposed the budget to expand the pipe in those areas. The blue print of the system to be spread and implemented in other villages.
around Tarutung has been proposed to the Major of Tarutung. In the next step, we will also develop the similar system to Lumban Sihobuk, the village next to Lumban Lobu. By increasing the power and charge of the motor system to 2 Hp, it will increase the water flow rate as high as 3000 liter/hour without changing the pipe distribution.

**Discussion**

When the system was first built in 2011, it was a totally failure since we did not expect that the voltage supply was not enough support the system in that village. When the pump was supplied with the electricity, the whole motor was broken. When we measured it, we found the voltage was dropped to 180V AC only. The drop voltage protector would shut down the system when drop voltage happened. Drop voltage would influence the performance of pumping system as well as ruining the components within it. Due to this, there would be a voltage gap between the motor coupling and the pump that increased the resistance’s value which caused the motor to break down.

Although the current capacity was 1600 liter/hour, it could be increased by upgrading the vertical multistage centrifugal pump to 3000 liter/hour without changing the design as shown in figure 5. All working process was carried out by the villagers, children and adults who worked on the plumbing for the entire week. The last installment of the whole system can be seen in figure 6 and the lightning arrester can be seen in figure 7.

![Figure 4. The map of water distribution system.](image-url)
Figure 5. The first phase of the project: (a) The natural water spring kept in the water tank before distributed 86 meters to the hill side, (b) the working process, and (c) the water tower and pipe distribution to the village.
Figure 6. The water distribution system with two vertical multistage centrifugal pumps in the fourth phase.

Figure 7. Lightning arresters made of tree’s pole.

The first budget proposed for the first phase was around US$1,880 (US$1 equal to 13,500 rupiahs) excluding the transportation of the experts to the area. The main budget was used for buying the pump and installing of the pipe. There was no fee expended for the workers since villagers worked hand in hand to build the system. Each phase had different kind of budget according to the needs of project done. For each step, we spent US$1,500 for buying backup system, stabilizers, drop voltage protectors, water tanks or towers, concrete reservoir and lightning arresters. Transportation is one issue that has to be considered when sending the equipment from city to the village. Since it is located far from the city as shown in figure 8. The village can be reached by 10 hours driving from Medan as the capital city of North Sumatera.

Now the Lumban Lobu village has clean water supply for most of the villagers, even though the plumbing system has not reached the outer part of the village such as the public primary school, the HKBP church or the community center. A further experiment will be conducted in order to see the quality of the water from the natural spring resource based on guidelines for drinking water quality by WHO[12-13]. We need to conduct this research, since the water also the primary source for cooking and drinking.
Conclusion
The first author and his families live in Lumban Lobu village where clean water was rare. Then, the push water pump was introduced and the 70 meters well making is not a better choice. The system is published with the blue print of the design in this journal in order to share the benefit of this system to others. Hopefully, all villages in Tarutung area where most of them face the similar condition can implement this system for better life in the village.

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