# EVALUATION OF MULTIPLE WELL SYSTEM IN SHALLOW AQUIFERS FOR PADDY IRRIGATION

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## ABSTRACT

*Groundwater from the first layer of the shallow aquifer is important to develop a sustainable water resources supply for paddy irrigation, especially in an area which is vulnerable to climate change and lack of surface water sources and facilities. The volume of groundwater is significant data to estimate the coverage area on paddy plantations and future development. Utilizing groundwater for irrigation can be an alternative to maximize grain production. Instead of reduction of risk due to climate, with sustainable water sources, farmers will increase production to maximize their income since the era of pandemics and disasters which impact food security. The research on shallow groundwater on multiple well system was conducted at MARDI Seberang Perai, Pulau Pinang. Result showed double well system (DWS) and Triple well system (TWS) improved the capacity of flowrate 37.7% and 50.46% respectively from the single well system(SWS). Estimated acreage paddy irrigated area increase from 2.64 ha to 3.95 ha and 4.97 ha based on pumping test conducted during the dry season.*

Keywords: *Groundwater, Tubewell, multiple well systems, shallow aquifers*

## INTRODUCTION

Groundwater is a valuable resource for agriculture particularly in areas where surface water is limited or unreliable (Ansari et al., 2021). Groundwater can be accessed through wells and used for irrigation, which can increase crop yields and improve food security (Zahid et al., 2006) (Misra, 2014).The groundwater irrigation in Malaysia is highly potential because most of the granary area in Malaysia is located at the river basin which is covered with alluvium deposits (Fauzie Jusoh. M et al., 2013). Alluvial aquifers in Peninsula Malaysia's coastline region are the most productive, with yields that typically range from 30 to 50 m3/h. (Fauzie Jusoh. M et al., 2013). The development of shallow tube wells has the potential to be a cost-effective alternative water supply for agriculture in the future to assist during the dry season and support small farmers and places outside granaries that still lack water. For agricultural usage, shallow tube wells are a type of groundwater abstraction method that are frequently utilized, especially in areas where water is limited. (Mukherji et al., 2018). Humans are now able to utilize very deep aquifers because of advancements in drilling and pumping technology, which facilitates the use of groundwater. A cheaper alternative to treated surface water could be groundwater (Mohammed & Ghazali, 2009). These wells are typically drilled to depths of up to 30 meters and can provide a reliable source of water for irrigation. Shallow tube wells can be an effective way to access groundwater for smallholder farmers, as they are relatively inexpensive to install and maintain compared to deeper wells(Zahid et al., 2006). They can also be easily powered by manual or motorized pumps, making them accessible to farmers with varying levels of resources. (Kuper et al., 2012). The discharge rate of a shallow well can vary depending on several factors, including the size of the well, the depth of the water table, the type of soil and rock formations surrounding the well, and the pumping rate(Wu et al., 2015). The discharge rate of a shallow well can be increased by increasing the pumping rate, which can be accomplished by using a larger pump or using multipoint well (Shi et al., 2020). This study is expected to provide insight into the performance of multiple well point system and its characteristic for irrigation usage for paddy by Improvising the yield of water capacity which can cater larger amount of water.

## MATERIALS AND METHODS

This study was conducted at the MARDI Seberang Perai research station, a centre of excellence for rice, to improve the water management system. A shallow alluvial area was chosen to test the Multiple well systems for use in rice cultivation. Specifically, the study was conducted at Block 6 with latitude and longitude 5.546856, and 100.461675 respectively (Figure 1). The soil drilling works to obtain soil character sample data and hydrometers are carried out. The type of soil is logged to be used as a reference and to know the type of soil in each layer of the shallow aquifer. Data is taken at every depth of 1.5 m up to 40 m into the ground. Table 1 showed the ilustrations of well and soil in the shallow aquifer. 3 units of shallow tubewells (Tubewell 1(TW1), Tubewell 2(TW2), and Tubewell 3(TW3)) were built using Rotary waterjet hand augers to evaluate the capacity of groundwater for irrigation. The specification of the tubewell were shown in Table 2. The schematic diagram of the multiple well systems is shown in figure 3.


**Figure 1. Map of MARDI Seberang Perai,Penang, Malaysia and location of the study area at Block 6 of**

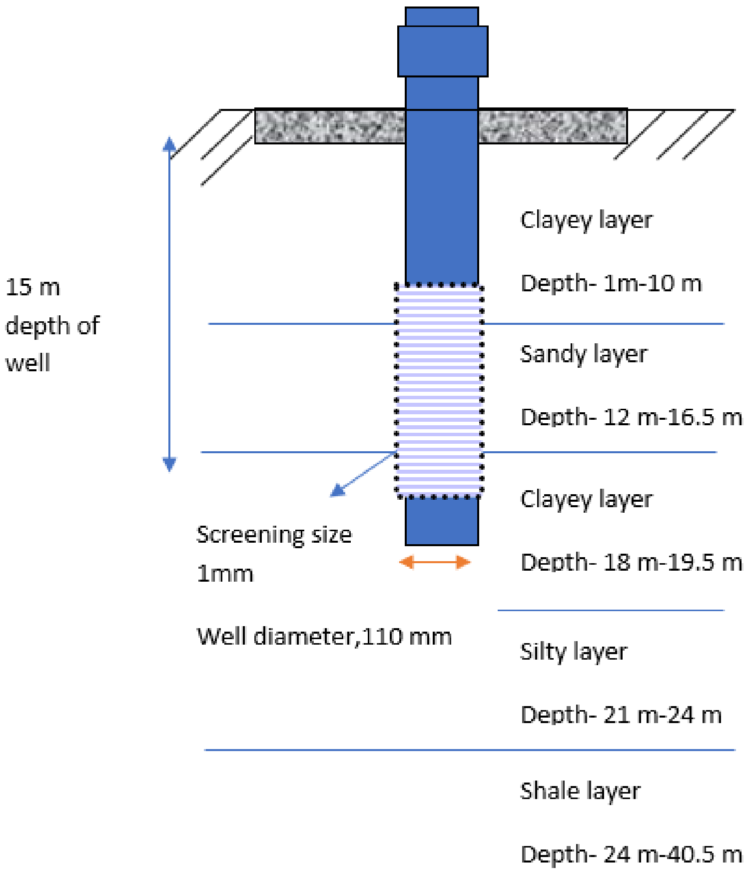


**Figure 2. Ilustration of Tubewell dimension, specification, and soil layer**

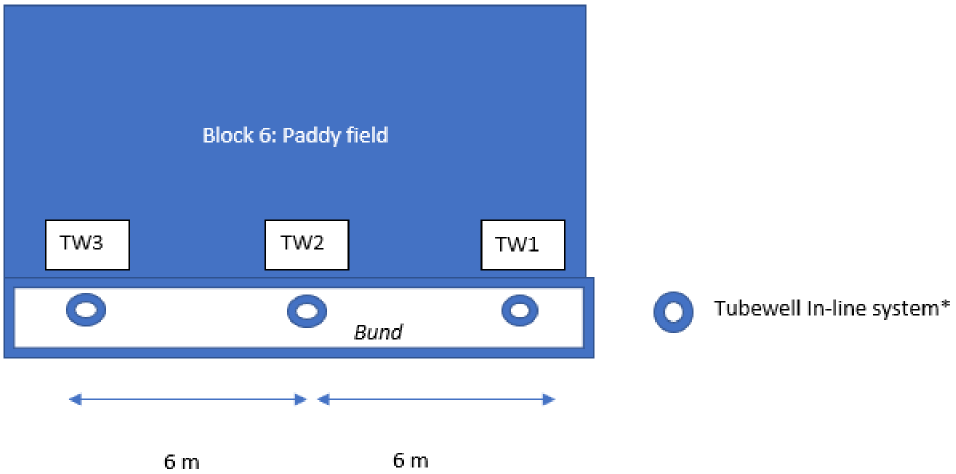


Figure 3. Schematic diagram of multiple well system

**In-line system is the well was built straight line side by side*.

**Table 2: Tubewell specifications**

| Tubewell | Static water level( SWL)(m) | Depth(m) | Diameter size(mm) |
|---|---|---|---|
| TW1 | 7 feet | 15 | 110 |
| TW2 | 4 feet | 15.2 | 110 |
| TW3 | 4.8 feet | 15.2 | 110 |

**Figure 4. Water pump**

**Figure 5. V-notch tank**

**Figure 6. The ruler soldered v-notch**

**Pumping test**

A pumping test was conducted to determine the characteristics and performance of the tubewell. During the test, the well is pumped at a constant rate, and measurements are taken to determine the hydraulic properties of the aquifer and the well. The test involved measuring the water level in the well before, during, and after pumping, as well as the rate of water being pumped. The 13 Hp portable end suction pump (figure 4) was installed to all tubewell for extraction of groundwater. The groundwater distribution was channelled using polyethene pipe to the triangular v-notch weir tank (figure 5) and measured the water level when passing through the weir. The ruler is soldered (figure 6) to the tank to facilitate data collection of head height, H. Comparison of the single well system, double well system and the triple well system was conducted (table 3). All pumping equipment was installed, and the pumping test was conducted for eight (8) hours based on the constant rate test.

**Table 3. Pumping test specifications**

| Date | Tubewell system | Nos Pump | No. of hours | Method of pumping test | Tubewell and Static water level,STW(m) |
|---|---|---|---|---|---|
| 3/3/2021 | Single well system(*SWS*) | 1 | 8 | Continuous | TW2(1.52) |
| 4/3/2021 | Double well system(DWS) | 2 | 8 | Continuous | TW2(1.21),TW3(1.31) |
| 5/3/2021 | Triple well system(TWS) | 3 | 8 | Continuous | TW1(1.28),TW2(1.25),TW3(1.30) |

This method involves pumping water from a groundwater well at a constant rate and measuring the drawdown in the well and the surrounding area. The data obtained from the pumping test can be used to estimate groundwater discharge. The calculation formula the flow rate Eq. (1)

$$Q = \frac{8}{15} C_d \left[\tan\frac{\theta}{2}\right] \left(\sqrt{2g}\right) h^{\frac{5}{2}} \qquad (1)$$

Q is the flow rate, in cubic meters per second ($m^3/s$)
$C_d$ is the discharge coefficient, which is a dimensionless constant that depends on the shape of the weir and the Reynolds number of the flow
θ is angle of *v-notch*
g is the velocity of the fluid as it approaches the weir, in meters per second (m/s)
h is the head of the liquid above the notch, in meters (m)

This data is then used to estimate the well's yield, which is the amount of water that can be pumped from the well over a certain period of time.

**Scheme irrigation water need and supply**
Paddy irrigation water supply was estimated by using the approximate method to calculated the coverage area can be supply from the shallow tubewell.

**Table 4. Approximate average $IN_{net}$ values for different climates and rice**

| Climate | Constant average irrigation need $IN_{net}$ |
|---|---|
| Humid tropical climate | 0.5 l/s/ha |
| Monsoon climate wet season | 0.5 l/s/ha |
| Monsoon climate dry season | 1.0 l/s/ha |
| Semi-arid climate wet season | 1.0 l/s/ha |
| Semi-arid climate dry season | 1.5 l/s/ha |
| Arid climate | 1.5 l/s/ha |
| Rice | 1.5 l/s/ha |

The FAO the approximate Net Scheme Irrigation need formula used for the calculation of area can be irrigated based on the result of groundwater flowrate, can be simplified as Eq. (2):

$SIN_{net}$ (l/s) = **Area** (ha) x $IN_{net}$ (l/s/ha). (2)

Where $SIN_{net}$= irrigation need for an entire area, $IN_{net}$= constant average irrigation need

In this study, Constant average irrigation for Monsoon climate wet season, monsoon climate dry season were used to estimate the irrigated area based on suggested by FAO.

## RESULTS AND DISCUSSION

Table 5 shows the result of the pumping test for a different type of good system based on the constant rate test and estimation using the v-notch weir formula. It shows the triple-well system (TWS) is the highest flow rate compared to double-well and single-well systems. The average flowrates are is 430 $m^3$/day in 8 hours pumping period. It is followed by a double well system (DWS) which is the flowrates, of 342 $m^3$/day. The lowest pumping rate for the Tubewell in-line system is the single well system (SWS) where the yield of groundwater is 213 $m^3$/day.

**Table 5. Result of pumping test**

| Tubewell (in-line system) | Averages Discharges.Q (m3/day) at 8 hrs pumped | Percentages flow increase (%) from single well system (SWS) |
|---|---|---|
| ***SWS*** | 213 | - |
| ***DWS*** | 342 | 37.70 |
| ***TWS*** | 430 | 50.46 |

The projected scheme coverage area for paddy irrigation using the tubewell system shows in Table 6. During the wet monsoon season, the coverage area for SWS can cover up to 4.92 ha area of paddy plantation for irrigated. For DWS, the coverage area during the wet season is 7.90 ha and the highest area by using the TWS where the area covers almost 10 ha irrigation scheme. During the dry season, all the system areas decrease by nearly 50% during the wet season 2.46 ha (SWS), 3.95 ha (DWS), and 4.97 ha (TWS) respectively.

**Table 6. Result of scheme irrigation need**

| Water supply | Average Discharge, l/s | Scheme coverage area during monsoon climate wet season, ha | Scheme coverage area during monsoon climate dry season, ha |
|---|---|---|---|
| ***SWS*** | 2.46 | 4.92 | 2.46 |
| ***DWS*** | 3.95 | 7.90 | 3.95 |
| ***TWS*** | 4.97 | 9.94 | 4.97 |

## CONCLUSIONS

A multiple-well system in a shallow aquifer can be used for paddy production, but it will depend on various factors such as the aquifer's characteristics, the depth of the water table, the crop's water requirements, and the availability of water resources.In general, paddy fields require a consistent and abundant supply of water throughout the growing season. In an unconfined aquifer, the water table fluctuates with changes in rainfall and pumping from wells. Therefore, a multiple-well system can be designed to maintain the water table at a desired level to ensure a consistent water supply to the paddy fields.Overall, a multiple-well system can be an effective way to manage water resources in an unconfined aquifer for paddy production, but it requires careful planning and management to ensure sustainable use of the aquifer.

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