Drilled wells water level data recording system for irrigation of rainfed rice using Arduino and pressure sensor

Muhammad Tahir Sapsal, Suhardi, Ahmad Munir and Dewi Pratiwi Sasmito

Agricultural Engineering Study Program, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

Email: muh.tahir@agri.unhas.ac.id

Abstract. The use of groundwater is one of the alternatives used to increase productivity in rainfed rice fields. Various researches and technologies have been developed to suppress the negative effects of overuse of groundwater. One important parameter is the change in the water level around the well during the pumping process, which is observed through the observation well. For that, we need an instrument to measure changes in water level in real-time. This instrument was developed using the HDL 300 submersible liquid level sensor, which utilizes pressure changes from the water level. To connect the sensor with the Arduino Uno microcontroller module using the HW685 Module. The calibration results show that the linearity of the change in the sensor value to the change in the water level reaches 99% following the equation $y = 86.297x + 73.522$.

1. Introduction

The success of rice cultivation is supported by various components, one of which is irrigation. However, there are still many rice fields in Indonesia that are not supported by the availability of technical irrigation. These lands only use rainwater as a source of irrigation; therefore, the rice cultivation process is stopped during the dry season. This land is known as rainfed rice fields. In order that rice cultivation can still be carried out in the dry season, farmers usually carry out water pumping, which can be sourced from rivers or groundwater. However, excessive groundwater exploitation, especially in agriculture, can lead to land subsidence, as happened in one of the agricultural areas in Bandung, West Java, which experienced land subsidence up to 6 cm/year [1].

Groundwater pumping in rainfed rice fields during the dry season can be minimized by constructing an embung so that the negative effects of pumping can also be suppressed. In addition, with the presence of embung, it is hoped that it can maintain the water level profile below the surface, even though groundwater pumping is carried out in the borehole around the reservoir. Embung is a form of water harvesting made in a small farm reservoir. This water harvesting can be used to reduce drought and enables the use of run-off beneficially [2]. In Tanasitololo Subdistrict, Wajo District, farmers have built several embung and collect water during the rainy season in the reservoir to be used during the dry season. In addition, water pumping from groundwater is also carried out, especially for land whose surface is higher than the surface of the reservoir water. Therefore, this location can be...
used to research to determine how much influence the embung has on changes in the water surface profile below the ground due to groundwater pumping. For this reason, an instrument that can be used to record changes in the water level during the pumping process is required, both from the reservoir and the borehole and the groundwater level profile between the reservoir and the well.

Changes in water level can be detected by several methods, including utilizing the capacitive properties of the medium of conductor or utilizing the time of sound reflection using ultrasound. Another way is to take advantage of pressure. This method has often been used to detect water level levels. For example, it is used to detect changes in sea level, which are then developed into a tsunami warning [3]. In this study, the method used utilizes changing hydrostatic pressure due to changes in the water level.

2. Methods
Measurement of changes in water level was carried out at embung and bore well, and three observation wells located between the reservoir and the bore well. These changes are recorded in real-time so that the data obtained can show the dynamics of changes in water level when pumping is carried out.

3. Design of instrumentation system
The purpose of this instrument is to record changes in water level data using a pressure sensor. The higher the water level, the higher the pressure. The sensor’s transfer function in this study is a pressure value converted into a current value. The depth of the well is about 8 - 10 meters, while the main well is 70 meters deep with a possible change in the water level during the pumping process of about 7 - 10 meters, and the depth of embung is 6 meters. Therefore, the sensor used must be able to detect a water surface depth of up to 10 meters with a current output of (I) 4 - 20 mAh. The read current is converted into a voltage (V) to be connected with an analog to digital data converter (ADC). After converting to digital, the data is translated into water level data for display and storage processes. The information is displayed on the LCD (liquid crystal display) and stored in memory storage along with the recording time using the RTC (real-time clock). System block diagram as shown in figure 1.

4. Hardware

![Figure 1. Block diagram of water level changes data aquation system.](image-url)
The need for components that meet the design referred to in the previous description consists of a pressure sensor using the HDL 300, which can be used to measure the depth of the water surface up to 500 meters with the resulting current ranging from 4 - 20 mAh. To convert the output current from the HDL 300 to a voltage, a Current to Voltage Converter module is used, namely the HW685 Module, which can convert the current into a voltage of 0 - 5 V. The voltage range is in accordance with the ADC used. The microcontroller used is the Arduino Uno module, an AVR microcontroller with a built-in ADC with a working voltage that can be set up to 5 V (the connection between the sensor to the microcontroller can be seen in figure 2). For storage using the SD card module and for designation time using the DS3231 RTC module. As a display, a 16 x 2 I2C LCD is used. The device is placed far from the PLN power source so that the power source uses a 12 V 7 Ah battery equipped with a 20 Wp solar power generator.

5. **Software design**

From reading digital data to data storage processes, instructions for the entire process are compiled using the Arduino IDE 1.8.13, which is based on C Language. The Arduino ADC port is connected to the HW865 Module via pin A0, and the voltage is converted to a water level value based on the sensor calibration results. Data is displayed continuously using an LCD connected to the I2C Arduino Uno port. Meanwhile, data storage into the micro SD module is done every minute (figure 2).

![Figure 2. Block diagram of water level data aquation system.](image)

6. **Performance test**

The test consists of two stages, namely (1) testing the response of the sensor to changes in the water level whose data is used for the calibration process and (2) testing the performance of the water level data acquisition.

Sensor response testing is done by connecting the sensor to a current to voltage converter, and the output is connected to the ADC port on the microcontroller. Data were collected using a pipe with a diameter of 5.08 cm, which was installed vertically as high as 450 cm and filled with water. The sensor is submerged slowly, and the ADC values read are recorded at changes in height every 25 cm. After the sensor reaches the bottom of the pipe, the sensor is lifted and tested three times. The data obtained were plotted to obtain an equation that shows the relationship between the mean ADC value reading and the water level.

The equation obtained is used to determine the water level based on the ADC value. This equation is the trendline from the test result data, which states the relationship between the water level and the ADC value and follows the equation of water level = a (ADC) + b where a is the slope value and b is
the intercept value. Furthermore, the water level reading performance test is carried out before the instrument is used to record data at the research location. Field testing was carried out at one of the observation points in the rainfed rice fields in Tanasitolo District, Wajo Regency (figure 3), which is the location of the main bore well. The test is carried out by marking the sensor cable every 1 m.

7. Results and discussion
8. Sensor response

The results of the sensor reading test process show that the sensor is able to respond to pressure changes sensitively. The pressure that occurs is hydrostatic pressure, where the test is carried out on a fluid that is not moving, and the pipe is not closed so that the shape of the pipe does not influence the pressure value obtained. Therefore the pressure at all points at a certain depth is equal. So that changes in surface height will be followed by changes in pressure read by the sensor. The results obtained from the test results at three times the data collection, the value obtained by the ADC tended to be consistent with an average deviation of 2 points. The results obtained are shown in figure 4.

![Figure 3. Testing location.](image-url)
Figure 4. ADC value according to water level.

Figure 3 shows that the change in the water level is followed linearly by the difference in the ADC value following the equation $y = 86.296x + 73.522$ where $y$ is the readable ADC value, and $x$ is the water level value in m units, with a determination coefficient of around 99%. This shows that the sensor can respond well to changes in water level. The highest ADC value obtained is 463 from the maximum value of 1023, and the electric current is converted from 4 to 20 mAh to 0 - 5 V. This indicates that this tool can still measure up to twice the depth tested ($\pm$ 10 m).

The calibration value obtained is then entered into the ADC data conversion process to study the water level data in the microcontroller by using the equation water level (m) = 0.0116 (ADC) - 0.8515. Then the data was collected again, and the following data were obtained:

Figure 5. Performance test result of water level measurement instrument.

The test results show shown as figure 5 that the designed instrument is able to show accurate measurements up to a depth of 5 m with a determination coefficient of more than 99%. It should be noted that the sensors used start measuring at a depth of 0.15 m., and in the calibration process, there is an offset of 73, so that at a depth reading of less than 0.73 m, the reading cannot be said to be accurate. So that the use of this system should be used at a depth of more than one m., which value is suitable for use at the research location. Besides, the use of this sensor has an accuracy similar to that of the aquaplump water level [4]. Besides, this system also does not have any moving parts, such as using the ultrasonic system [5]. The difference can be found in the measurement range, where the
HDL 300 can reach 5 meters, even up to 10 m. The data obtained also indicates that the density value of the water at the research location is the same as the water during the calibration process. The difference in the density value can affect the value of the hydrostatic pressure obtained [6]. Where the fluid with a greater density also has a large hydrostatic pressure value. So that for the use of this sensor in locations that have different density values for the fluid, it is necessary to do a recalibration process.

![Figure 6. installation of instrument in research location.](image)

The application in the research location utilizes a 20 Wp solar panel as a power source, which is equipped with a 10 A solar charger controller and a 12 V, 7Ah battery. In installation of instrument in research location (figure 6)

9. Conclusion
The instrument for recording and reading data on changes in groundwater level has been successfully made. The pressure sensor used, the HDL-300, can detect changes in the water level well with a determination coefficient of more than 99%.

Acknowledgment
Our gratitude goes to the research and community service institute of Hasanuddin University and Directorate of Research and Community Service, Higher Education, Ministry of research and technology for the assistance of research funds given to us through the PDUPT Scheme in 2020 with Contract No. 007 /SP2H/AMD/LT/DRPM/2020 entitled: Study on the Optimization of Utilization of Reservoir (Embung) and Groundwater in Increasing Productivity of Rainfed paddy field in a Sustainable.

References
[1] Sidiq T P, Gumilar I, Abidin H Z and Gamal M 2019 Land subsidence induced by agriculture activity in Bandung, West Java Indonesia *IOP Conf. Ser. Earth Environ. Sci.* 389
[2] Oweis T and Hachum A 2009 Water harvesting for improved rainfed agriculture in the dry environments *Rainfed Agric. unlocking potential* 164–82
[3] Manuhutu L and Pramono Y H 2015 Analisa ketinggian permukaan air laut berbasis tekanan atmosfer untuk system peringatan dini Tsunami *Prosiding Seminar Nasional Fisika* (E-
Journal) vol 4 pp SNF2015-IX

[4] Sapsal M T and Sjahrir R 2019 Rainfall meter using arduino and aquaplumb water level sensor
IOP Conference Series: Earth and Environmental Science vol 355 (IOP Publishing) p 12103

[5] Sulistyowati R, Sujono H A and Musthofa A K 2015 Sistem pendeteksi banjir berbasis sensor
ultrasonik dan mikrokontroler dengan media komunikasi sms gate way Skripsi. Fak. Teknol.
Ind. Inst. Teknol. Adhi Tama Surabaya

[6] Kasli E and Aminullah A 2016 Pengaruh massa jenis benda terhadap tekanan hidrostatis J.
Pendidik. Geos. 1