Temperature is among the most common environmental parameters of interest across various fields. In agriculture, all biological processes are tied to the temperature conditions of both air and soil [1]–[3], which are to be closely monitored and controlled. As a result, one of the goals for the Autonomous Wireless Agrometeorology Station is the recurring measurement of these parameters at the ground level and 1 metre above the ground. Although [2] and [4] demonstrate that soil temperature needs sampling at multiple depths, this project only prefers data of surface soil since the durability of sensors are not going to be taken care of and the technique of reading soil temperature in this scope is regardless of the depth where measurements take place. This section considers the choices for the corresponding sensors.

In this project, most modules are expected to be positioned off the ground. The microcontroller circuit board could be set up at some point above the ground level as the convergence point, which allows a temperature sensor to be integrated with minimal wiring; in turn, the temperature sensor at the ground level needs connecting via a cable of at least 1 metre. The choices for such devices are made from the comparison of available options in Vietnam as depicted in Table 1. All the fields are obtained from the device datasheets and/or the 2 suppliers Hshop and Thegioiic, with an exception of pricing data for BME280, whose availability is only found at ProE company when this thesis is conducted.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Part name | Operational voltage | Typical current/power consumption | Temperature output range | Data accuracy | Resolution | Available package(s) | Price | Communication protocol/method | Additional features |
| SHT30 | 2.15 to 5.5 V | 0.2 to 1500 µA | -40 to 125 ℃ | ±0.3 ℃ | 0.015 ℃ (16-bit) | * 11 x 13 mm breakout board * 50-cm long waterproof probe | 85,000 to 255,000 VND | I2C | Humidity sensing |
| SHT31 | 2.5 to 5.5 V | 0.2 to 1500 µA | -40 to 125 ℃ | ±0.3 ℃ | 0.015 ℃ (16-bit) | * 2.5 x 2.5 x 0.9 mm IC * 13.1 x 10.4 mm breakout board | 57,000 to 84,000 VND | I2C | Humidity sensing |
| SHTC3 | 5 to 28 V | < 0.05 W | -40 to 125 ℃ | ±0.2 ℃ | 0.01 ℃ | 50-cm probe | 195,000 to 285,000 VND | RS-485 Modbus | Humidity sensing |
| TMP435ADGSR | 2.7 to 5.5 V | 3 µA to 6 mA | -60 to 150 ℃ | ±1.25 ℃ | 12-bit | 3 x 3 x 0.5 mm (10-VSSOP) | 89,000 VND | SMBus |  |
| AHT20 | 2 to 5.5 V | 0.25 to 23 µA | -40 to 85 ℃ | ±0.3 ℃ | 0.01 ℃ | 10.4 x 15 mm breakout board | 27,000 VND | I2C | Humidity sensing |
| SMT172 | 2.7 to 5.5 V | 0 to 70 µA | -45 to 130 ℃ | ±0.25 ℃ | N/A | 4.58 x 4.58 x 3.86 mm (TO-92) | 93,000 VND | PWM |  |
| SHT20 | 2.1 to 3.6 V | 0.15 to 330 µA | -40 to 125 ℃ | ±0.3 ℃ | 0.01 ℃ (14-bit) to 0.04 ℃ (12-bit) | 50-cm probe | 294,000 VND | I2C | Humidity sensing |
| AM2315 | 3.5 to 5.5 V | 10 to 500 µA | -40 to 125 ℃ | ±0.1 ℃ | 0.1 ℃ (16-bit) | 50-cm probe | 830,000 VND | I2C | Humidity sensing |
| HTU21 | 1.5 to 3.6 V | 0.02 to 500 µA | -40 to 125 ℃ | ±0.3 ℃ | 0.01 ℃ (14-bit) to 0.04 ℃ (12-bit) | 21 x 16 mm breakout board | 49,000 VND | I2C | Humidity sensing |
| DHT11 | 3 to 5.5 V | 100 µA  to 2.5 mA | 0 to 50 ℃ | ±2 ℃ | 1 ℃  (8-bit) | 15.5 x 12 x 5.5 mm | 34,000 VND | Single-Wire Two-Way | Humidity sensing |
| DHT12 | 2.7 to 5.5 V | 30 to 150 µA | -20 to 60 ℃ | ±0.5 ℃ | 0.1 ℃  (16-bit) | * 12.3 x 7.5 x 4.7 mm * 2.1 x 1.3 cm breakout board | 67,000 to 72,000 VND | I2C, One-Wire | Humidity sensing |
| DHT21 | 3.3 to 5.5 V | 15 to 1200 µA | -40 to 80 ℃ | ±0.5 ℃ | 0.1 ℃ | 59 x 26.6 x 14 mm; extended wires up to 20 m | 103,000 VND | One-Wire | Humidity sensing |
| DHT22 | 3.3 to 5.5 V | 40 µA  to 1.5 mA | -40 to 80 ℃ | ±0.5 ℃ | 0.1 ℃ | * 25.1 x 15.1 x 7.7 mm * 58.8 x 26.7 x 13.8 mm; extended wires up to 100 m * 27 x 59 x 13.5 mm breakout board | 90,000 to 120,000 VND | One-Wire | Humidity sensing |
| LM35D | 4 to 30 V | 56 to 141 µA | 0 to 100 ℃ | ±1.5 ℃ | 10 mV/℃ | 4.58 x 4.58 x 3.86 mm (TO-92) | 45,000 VND | Analogue |  |
| LM335 | 2.92 to 3.04 V | 450 µA  to 5 mA | -40 to 125 ℃ | 1 to 9 ℃ | 10 mV/K | 4.58 x 4.58 x 3.86 mm (TO-92) | 15,000 VND | Analogue |  |
| LM75A | 2.7 to 5.5 V | 4 to 500 µA | -55 to 125 ℃ | ±2 to ±3 ℃ | 0.5 ℃  (9-bit) | 38 x 16 mm breakout board | 37,000 VND | I2C |  |
| Si7021 | 1.9 to 3.6 V | 0.6 to 180 µA;  up to 4 mA during transmissions | -40 to 125 ℃ | ±0.3 ℃ | 14-bit to 11-bit | 15.6 x 15.7 mm | 182,000 VND | I2C | Humidity sensing |
| DS18B20 | 3.0 to 5.5 V | 750 nA  to 1.5 mA | -55 to 125 ℃ | ±0.5 to ±2 ℃ | 0.5 ℃  (9-bit) to 0.0625 ℃ (12-bit) | * 4.58 x 4.58 x 3.86 mm (TO-92) * 1-m waterproof probe | 29,000 to 85,000 VND | One-Wire |  |
| BMP180 | 1.8 to 3.6 V | 0.1 to 650 µA | -40 to 85 ℃ | ±0.5 ℃ | 0.1 ℃ | 21 x 18 mm breakout board | 15,000 VND | I2C | Pressure sensing |
| BMP280 | 1.71 to 3.6 V | 0.1 to 720 µA | -40 to 85 ℃ | ±0.5 ℃ | 0.0003 ℃ (20-bit) to 0.0050 ℃ (16-bit) | 11.5 x 15 mm breakout board | 18,000 VND | I2C, SPI | Pressure sensing |
| BME280 | 1.71 to 3.6 V | 0.1 to 714 µA | -40 to 85 ℃ | ±0.5 ℃ | 0.01 ℃ | 16 x 1 mm breakout board | 140,000 to 650,000 VND | I2C, SPI | Humidity and pressure sensing |
| BME680 | 1.71 to 3.6 V | 0.15 to 849 µA | -40 to 85 ℃ | ±0.5 ℃ | 0.01 ℃ | 15 x 19 mm breakout board | 278,000 VND | I2C, SPI | Gas, humidity, and pressure sensing |
| PT100 | (type- and grade-dependent) | | | | | | 24,000 to 289,000 VND | Analogue |  |

Table 1. Comparison of choices for the temperature sensors

For a temperature sensor positioned at ground level, there are 8 options to be considered: SHT30, SHTC3, SMT172, SHT20, AM2315, DHT21, DHT22, and DS18B20.

[1] S. Das, “The Role of Temperature Sensor in Farming,” *Al Ardh Alkhadra*, 2022. https://www.aaaksc.com/temperature-sensor-farming/.

[2] H. Hao, F. Yu, and Q. Li, “Soil Temperature Prediction Using Convolutional Neural Network Based on Ensemble Empirical Mode Decomposition,” *IEEE Access*, vol. 9, pp. 4084–4096, 2021, doi: 10.1109/ACCESS.2020.3048028.

[3] A. F. Subahi and K. E. Bouazza, “An Intelligent IoT-Based System Design for Controlling and Monitoring Greenhouse Temperature,” *IEEE Access*, vol. 8, pp. 125488–125500, 2020, doi: 10.1109/ACCESS.2020.3007955.

[4] World Meteorological Organization, “Measurement of temperature,” in *Guide to meteorological instruments and methods of observation*, 7th ed., World Meteorological Organization, 2008.