

SMART ENVIRONMENTAL MONITORING SYSTEM, INCLUDING THE COMPONENTS, THEIR FUNCTIONS, ESTIMATED COSTS, TYPE OF COMMUNICATION INTERFACES, POWER SUPPLY REQUIREMENTS, AND A SUITABLE MICROCONTROLLER.

Component	Function	Communication Interface	Power Supply Requirements	Estimated Cost (USD)	Additional Notes
Microcontroller (MCU)	Central processing unit to manage sensor data and control	UART, I2C, SPI, GPIO	3.3V/5V	\$5 - \$10	ESP32 (preferred) for Wi-Fi, Bluetooth, multiple GPIOs; alternatives: Arduino Mega or STM32
Temperature & Humidity Sensor (DHT22)	Measures ambient temperature and humidity	Digital (1-wire)	3.3V - 5V	\$3 - \$5	Accurate readings with minimal power; suitable for indoor/outdoor environments
Air Quality Sensor (MQ135)	Detects harmful gases (CO2, NH3, NOx, etc.)	Analog	5V	\$6 - \$10	Can be calibrated; sensitive to various gases; requires periodic cleaning and recalibration
Particulate Matter Sensor (PMS5003)	Measures PM1.0, PM2.5, and PM10 levels in the air	UART (Serial)	5V	\$15 - \$25	High accuracy for indoor/outdoor air quality monitoring; includes a built-in fan for air intake
Light Intensity Sensor (BH1750)	Measures ambient light intensity	I2C	3.3V - 5V	\$3 - \$6	Low power consumption; suitable for detecting sunlight

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Weather Station Core Components	Temperature Sensor (DS18B20)	1-Wire	3.3V - 5V	\$1 - \$2	High precision; requires pull-up resistor
	Humidity Sensor (DHT22)	Digital (I2C)	3.3V - 5V	\$3 - \$5	Digital output; includes temperature measurement
	Soil Moisture Sensor (Capacitive)	Analog	3.3V - 5V	\$2 - \$4	Capacitive sensor is more accurate and durable than resistive types; avoids corrosion issues
Environmental Sensors	Rain Sensor (YL-83)	Digital/Analog	5V	\$1 - \$3	Simple sensor; requires additional circuitry for signal stabilization
	Wind Speed Sensor (Anemometer)	Digital (Pulse)	5V	\$10 - \$15	Often used with wind direction sensors for comprehensive weather monitoring
	Wind Direction Sensor	Analog	5V	\$15 - \$20	Typically used alongside an anemometer; provides 0-360° directional output
Atmospheric & Radiation Sensors	Barometric Pressure Sensor (BMP280)	I2C/SPI	3.3V	\$5 - \$8	Low power; also measures altitude; highly accurate; ideal for weather stations
	UV Sensor (VEML6070)	I2C	3.3V	\$4 - \$7	Ideal for monitoring UV exposure levels; commonly used in outdoor weather systems

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CO2 Sensor (MH-Z19B)	Measures CO2 concentration in the air	UART (Serial)	5V	\$25 - \$35	High precision; suitable for indoor air quality monitoring; supports PWM and UART output
Sound Level Sensor (LM393)	Measures ambient noise levels	Analog/Digital	3.3V - 5V	\$4 - \$7	Useful for noise pollution monitoring; adjustable sensitivity
Solar Panel (10W - 20W)	Provides power to the system	-	12V (nominal), with a regulator	\$20 - \$40	Choose higher wattage for more power; must be compatible with the charging circuit
Battery (Li-ion, 3.7V, 2000mAh - 5000mAh)	Stores energy from the solar panel for backup	-	3.7V	\$7 - \$15	Ensure battery management with overcharge/over-discharge protection
Battery Management System (BMS)	Protects and manages Li-ion battery charging/discharging	-	3.3V - 5V	\$5 - \$10	Critical for maintaining battery health and longevity; prevents overcharging
Voltage Regulator (LM2596 or LM7805)	Regulates power supply to the required voltage levels	-	3V, 5V, 12V	\$2 - \$5	Efficient DC-DC converter; essential for stabilizing input from solar panels or batteries
RTC Module (DS3231)	Keeps track of real-time clock data	I2C	3.3V - 5V	\$3 - \$5	Highly accurate with temperature compensation; crucial for time-

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GSM Module (SIM800L)	Provides cellular communication for remote data access	UART (Serial)	3.3V - 4.4V	\$10 - \$15	stamped data logging
					Ideal for remote locations without Wi-Fi; supports SMS, GPRS, and voice calls
LoRa Module (SX1278)	Long-range wireless communication for remote monitoring	SPI	3.3V - 5V	\$10 - \$20	Enables communication over long distances; suitable for IoT applications in remote areas
Wi-Fi Module (ESP8266, if not using ESP32)	Provides Wi-Fi connectivity	UART (Serial)	3.3V	\$4 - \$7	Provides wireless data transmission for real-time monitoring and cloud integration
Bluetooth Module (HC-05)	Enables Bluetooth communication for local data transfer	UART (Serial)	3.3V - 5V	\$5 - \$8	Ideal for local control and setup; can be paired with mobile apps for data visualization
SD Card Module (with microSD card)	For local data storage	SPI	3.3V - 5V	\$3 - \$5	Essential for logging data in environments without reliable internet connectivity
PCB and Miscellaneous Components	Connects all components (resistors, capacitors, connectors, etc.)	-	-	\$15 - \$25	Includes mounting, headers, and basic electronics; critical for integrating and organizing components

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Weatherproof Enclosure	Protects electronics from environmental factors	-	-	\$10 - \$30	Necessary for outdoor applications; ensure proper ventilation and protection against water ingress
OLED Display (128x64, SSD1306)	Displays sensor data and status	I2C	3.3V - 5V	\$5 - \$8	Useful for on-site monitoring and configuration; low power consumption
Relay Module (2 Channel)	Controls external devices (fans, pumps, etc.)	Digital (GPIO)	5V	\$3 - \$6	Allows automation of connected devices based on environmental parameters