Application in Home Smart Farms

Integration of Sustainable Technologies in Home Farming

A sustainable and self-sufficient agricultural system at home is created through the integration of rainwater harvesting and droplet energy conversion technologies into home-based smart farms. These type of systems support resource utilization, minimize dependence on external inputs, and optimize operational productivity (Movva, n.d).

For home farming systems, one of the key aspects to ensure the plant's growth is to have environmental monitoring systems that provide optimal conditions for each specific crop. In particular, DHT22 monitors the temperature and humidity, while the TEMT6000 measures the amount of light received to facilitate a precise atmosphere with controlled lighting conditions. The sensors determine when to apply water by determining the moisture content of the soil. Likewise, the DS18B20 sensor keeps an eye on water temperature for water quality control, which is an essential component of hydroponics or aquaponics. The Sensirion SCD30 is a different technology that monitors temperature, humidity, and CO2 levels to provide vital information on air quality. Together, these sensors allow for real-time data collection and provide farmers with advice on how to establish the perfect growth environment using easy-to-follow techniques.A sustainable and self-sufficient agricultural systems at households is created through the integration of rainwater harvesting and droplet energy conversion technologies into home-based smart farms. These types of systems support resource utilization, minimize dependence on external inputs, and optimize operational productivity (Movva, n.d).

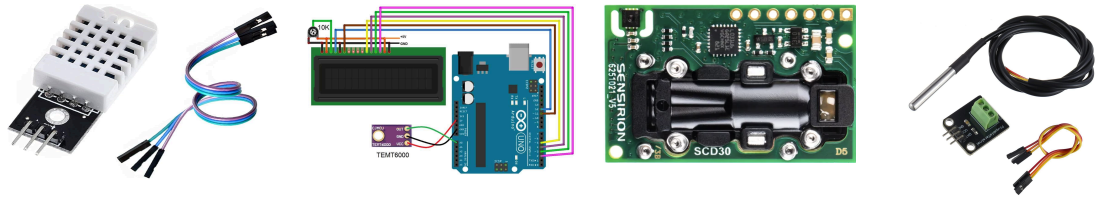

Fig10,11,12,13; **Fig 10.** DHT22 monitor **Fig 11**.TEMT60000 **Fig 12.** Sensirion SCD30 **Fig 13.** DS18B20 Sensor

Microcontrollers such as Raspberry Pi or Arduino control actuators to process data from the sensors and perform automation tasks based on predefined algorithms (Jindarat & Wuttidittachotti, n.d.). Some of the actuators include submersible pumps or sprinklers that automatically discharge water efficiently to the plants as well as LED grow lights to enhance photosynthesis in low- light conditions, while servo motors adjust the angles of the solar panels to maximize energy consumption.

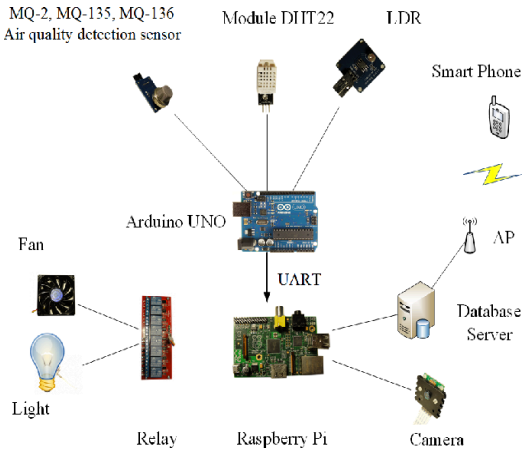

Fig 14. A block diagram of a Smart Farm Monitoring System using Raspberry Pi and Arduino

An essential part of these systems is power management, which guarantees continuous operation. Wind turbines are an optional addition to solar energy generation, which is a renewable energy source. The charge controllers regulate the energy flow from these sources to lithium-ion battery packs, which store energy for use in low-light or low-wind or dark hours (Rani et al., 2021). Rainwater harvesting systems supplemented with triboelectric nanogenerators, or piezoelectric devices, recover extra electricity from raindrop kinetic energy, contributing to the energy requirements of the farm (Rani et al., 2021). The harvested energy is used to power the sensors, lights, and actuators, thereby reducing external energy dependencies (Gonsalves et al., n.d.).

Smart integrated control is achieved by Arduino or Raspberry Pi where sensors, actuators, and power management systems are combined together. A smartphone application makes it possible to observe and operate these systems remotely, allowing the user to make quick adjustments to settings. Intelligent switchable windows are one example of an intelligent infrastructure that further improves the system by modifying solar light penetration in response to outside lighting conditions to create the best space for plants to receive energy.

This integrated approach is exhibited in a home smart farm where rainwater is collected, filtered, and stored for irrigation, while piezoelectric devices produce energy from the impact of falling raindrops. The power soil moisture sensors, growing lights, and water pumps are able to be operated by using these stored energies. A central control unit enables automated irrigation and environmental monitoring, keeping growing conditions optimal for plants. The self-sufficient system also stores energy in lithium-ion batteries, backed by solar panels and optional wind turbines, providing a continuous power supply. This self-sufficient system not only reduces negative environmental impact but also increases resource efficiency, democratizing advanced farming technologies in households, thus contributing positively to sustainable modes of living (Johnson, 2024).

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