AN INTELLIGENT SELF-REGULATING GREEN ROOF SYSTEM FOR HEAT REDUCTION AND ENVIRONMENTAL SUSTAINABILITY

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Introduction:

1. Urbanization has been growing at a rapid pace in recent years. This has led to an increase in temperatures, a decrease in greenery, and an increase in energy consumption in buildings. One of the main issues in urban areas is the urban heat island effect. In this phenomenon, the buildings, roads, and concrete structures absorb heat and raise the temperature of the surrounding environment. This increases the temperature inside the buildings and the energy consumption of the cooling devices. Green roof technology is one of the most important solutions in reducing temperatures, improving air quality, and increasing environmental sustainability. This technology involves planting vegetation on the roofs of buildings. However, traditional green roof technology involves regular maintenance and monitoring of the roof. This is challenging in modern times.
2. With the advancement of Internet of Things (IoT) technology, smart technology can be developed that can monitor the environmental conditions and automate devices. Temperature, humidity, light, and soil moisture sensors can be used to monitor the environmental conditions on the roof. A microcontroller can be used to monitor the sensor data and automate the irrigation and ventilation devices. Solar power can be utilized to make the system energy efficient and not dependent on the external power supply. This makes the system suitable for both rural and urban areas. Solar energy can be used as a source of renewable energy in the system, which will make it energy efficient and not dependent on any external source of electricity. This will make the system appropriate for both urban and rural areas. According to various studies, it has been found that green roofs reduce temperatures, save energy, and are environmentally sustainable. However, it has been observed that the existing green roofs are not fully automated.

Objectives:

1. Design and development of an intelligent self-regulating green roof system with the help of solar energy.
2. Monitoring of environmental conditions such as temperature, humidity, light intensity, and soil moisture with the help of suitable sensors.
3. Automatic control of the irrigation system based on the soil moisture condition without the involvement of a human operator
4. Reduction of heat on the rooftops of buildings to enhance thermal comfort inside buildings.
5. Conservation of water by providing irrigation to plants when the soil becomes dry.
6. Use of solar energy to make the system energy-efficient and eco-friendly.
7. Design and development of a low-maintenance and automated system for buildings in urban as well as rural areas.

Methodology:

1. The proposed system is designed using IoT devices, sensors, and a solar-powered setup. First, a green roof structure is prepared with layers like waterproofing, soil, and plants to support vegetation and reduce heat.
2. Sensors such as soil moisture, temperature, humidity, and light sensors are placed on the rooftop to monitor environmental conditions in real time. These sensors continuously collect data and send it to a microcontroller like Arduino or Raspberry Pi.
3. The microcontroller processes the data and makes decisions based on preset conditions. If the soil becomes dry, the system automatically turns ON the water pump to irrigate the plants. Once the soil reaches the required moisture level, the pump is turned OFF to avoid water wastage.
4. Similarly, when the temperature rises above a certain limit, a ventilation fan is activated to reduce heat on the rooftop. This helps maintain a suitable environment for plant growth and improves cooling.
5. The entire system is powered using a solar panel and battery, making it energy-efficient and independent of external electricity.
6. Optionally, the system can send data to a cloud platform for monitoring. Overall, the system works automatically without human intervention and ensures efficient water usage, temperature control, and sustainable operation. The workflow is shown in the figure 1.

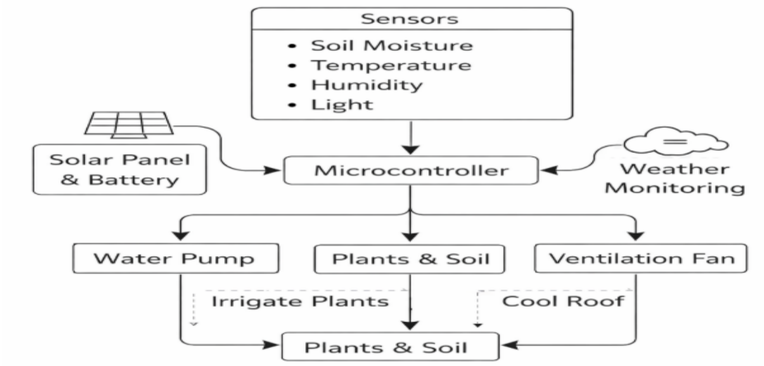
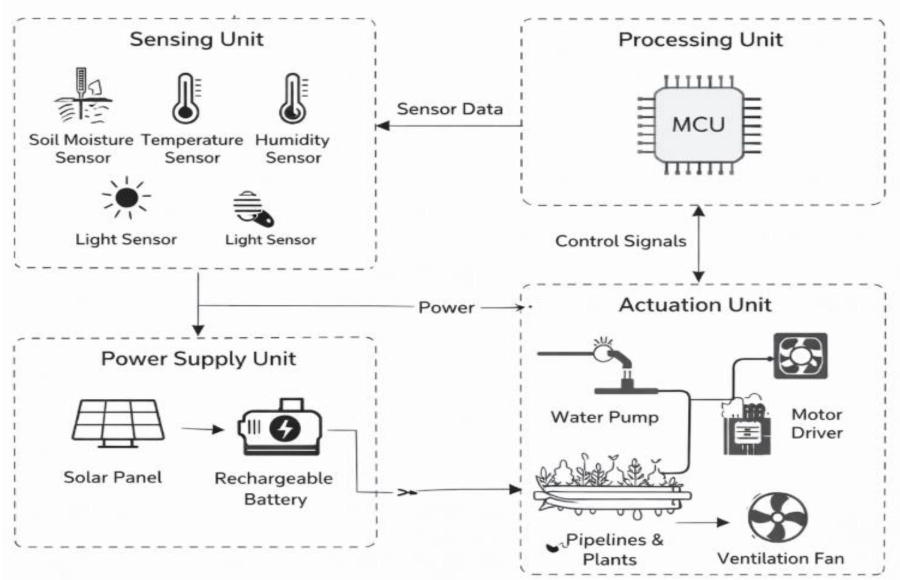


Figure 1. Solar-powered green roof system flowchart

Result and Conclusion:

1. The project successfully demonstrates the design of an intelligent self-regulating green roof system for heat reduction and plant maintenance. By using IoT sensors, the system monitors key parameters such as soil moisture, temperature, humidity, and light in real time.
2. The microcontroller processes this data and automatically controls the irrigation pump and ventilation fan. When the soil is dry, water is supplied, and when the temperature rises, the fan helps in cooling the rooftop.
3. The green roof structure, along with proper water control, provides a natural cooling effect and supports healthy plant growth. The use of solar energy makes the system energy-efficient and independent of external power sources. The system architecture is depicted in figure 2.
4. The system reduces water wastage by providing irrigation only when required and minimizes human effort through automation. Real-time monitoring improves system efficiency and ensures better environmental conditions.
5. Overall, the project shows that combining green roof technology with IoT and renewable energy can effectively reduce heat, save energy, and promote sustainable living in both urban and rural areas.

Figure 2. System Architecture



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Future Scope:

The proposed intelligent green roof system can be further enhanced by integrating advanced technologies and expanding its applications. With improvements in automation, monitoring, and energy efficiency, the system can become more reliable, scalable, and suitable for modern smart environments.

The future scope of this project includes:

1. Addition of advanced sensors (rain, air quality, sunlight intensity) for better monitoring
2. Integration with mobile app or cloud platform for real-time tracking and control
3. Use of Artificial Intelligence for predictive irrigation and smart decision-making
4. Improvement in solar power system using higher capacity panels and batteries
5. Integration with rainwater harvesting systems for efficient water usage