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The Mobile Smart Water Supply Infrastructure Powered by Renewable Energy in Errabu Village, Sumenep, Madura, Indonesia

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ABSTRACT

Purpose: The mobile smart water supply infrastructure powered by renewable energy in Errabu Village, Sumenep, Madura, Indonesia, aims to enhance agricultural food security. This system integrates smart technology and renewable energy to optimize water resource management and support agriculture in impoverished and underdeveloped areas. Mobile and Smart Concept, allows flexibility in water distribution, enabling access to hard-to-reach areas. Utilizes sensors and IoT devices to monitor and manage water usage efficiently.

Design/methodology/approach: Renewable Energy, utilizes solarenergy to operate the water supply system, reducing dependence on fossil fuels. Enhances sustainability by reducing carbon emissions and environmental impact.

Findings: Solutions for Dry Land, employs water-saving drip or sprinkler irrigation technology to boost productivity in dry lands. Optimizes water usage for agriculture, thereby increasing yields on previously unproductive land. Food Security, with better access to water, farmers can enhance their agricultural output, contributing to local food security. Enables farmers to grow a variety of crops, increasing food diversity and income. Social and Economic Impact, enhances the capacity of local farmers through training and access to new technologies. By improving agricultural yields, it is expected to reduce poverty levels in the village. Implementation and Collaboration, collaboration between the government, educational institutions, and the community is necessary to design and implement this system. Seeking funding sources from the government or donor agencies to support the development of this infrastructure.

Paper type: Research paper

Keyword: *Mobile, Smart, Water Supply, Renewable Energy.*

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I. INTRODUCTION

Mobile Smart Water Supply Infrastructure Powered by Renewable Energy is an innovative concept that integrates mobile and intelligent systems with renewable energy sources to ensure efficient, sustainable, and accessible water distribution. Errabu Village, located in Sumenep on Madura Island, Indonesia, has been actively implementing renewable energy initiatives to enhance the quality of life for its residents. One notable project is the installation of solar-powered water pumps to support agricultural activities. These pumps utilize solar energy to extract water, providing a sustainable solution for irrigation needs. In addition to solar-powered water pumps, the village has benefited from the installation of solar-powered street lighting. The Ministry of Energy and Mineral Resources (ESDM) has installed 55 units of solar-powered street lights in Sumenep Regency, including Errabu

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Village. This initiative aims to improve public safety and reduce reliance on conventional electricity sources. ESDM These efforts are part of a broader strategy to promote renewable energy in rural areas of Indonesia, aligning with the government's goal to achieve net-zero emissions by 2060. The adoption of renewable energy technologies in villages like Errabu not only addresses energy needs but also contributes to environmental sustainability and economic development.

A. Literature Review

Prototype Technology Robotic Automatic Green Irrigation for Sumber Surya Farmer Group in Errabu Village. The Robotic Automatic Green Irrigation technology is designed to support intelligent and efficient agricultural irrigation by integrating sensors, actuators, microcontrollers, and renewable energy sources. Key Components of the Technology, Soil Moisture Sensor Measures soil water content to determine irrigation needs. Type Capacitance-based soil moisture sensor. Weather Sensor, Function Monitors environmental parameters to aid in irrigation decision-making. DHT22 Measures air temperature and humidity. Pluviometer: Measures rainfall. Actuator Controls water flow based on sensor data. Type Pump motor for automated irrigation. Microcontroller or Mini Computer Processes sensor data and controls the actuators. Types: Arduino For basic applications. Raspberry Pi For more complex data processing. ESP32 Combines microcontroller functions with WiFi communication. Communication Module Facilitates communication between sensors, microcontrollers, and remote control devices. Types: WiFi (ESP8266/ESP32) For local networks. GSM For cellular networks. LoRa For long-range communication. Software and Algorithms Processes sensor data, automates decision-making, and provides a monitoring interface. Programming Languages Arduino IDE For Arduino. Python For Raspberry Pi. User interface for remote monitoring and system control. Materials for the Prototype Automatic Robotic Vehicle, A robotic framework that can be controlled using RC Control via an Android App. Sprayer system for water distribution in agricultural, plantation, or livestock areas. Water Tank 200 liters. Equipped with an automated spraying system. Energy Source Rechargeable Battery Can be recharged using solar panels, ensuring eco-friendly operation. Electronic Components PCB (Printed Circuit Board) For the main circuitry. Components like resistors, capacitors, transistors, and others. Mechanical Materials Robotic vehicle framework to protect electronic devices. Electrical and data cables with waterproof connectors for outdoor installations. Benefits of the Technology Irrigation Efficiency Automatically adjusts water distribution based on environmental data, reducing water wastage. Renewable Energy Utilizes solar panels for energy, minimizing reliance on fossil fuels. Remote Monitoring and Control IoT-based systems enable farmers to monitor and control irrigation via a mobile application. Improved Agricultural Productivity Provides a modern solution to ensure optimal crop yields through smarter irrigation. Lower Operational Costs Reduces irrigation expenses by leveraging solar energy and automation. Implementation Phases Needs Assessment Survey the land and irrigation requirements of the Sumber Surya Farmer Group. Prototype Design Develop the system based on local conditions and needs. Prototype Testing Conduct trials in partner agricultural areas to evaluate effectiveness. User Training Educate farmers on operating and maintaining the system. Evaluation and Optimization Collect feedback and refine the system for better performance [1]-[11]

II. METHODS

Conduct solar irradiance and wind speed analysis for energy generation potential. Survey existing water sources, including wells, rivers, and seasonal rainwater. Deploy mobile water supply units powered by solar energy. Local stakeholders in the planning and operation of the systems. Conduct workshops to ensure community understanding and ownership. Geographic mapping using drones or GPS tools. Set up solar-powered water pumps and IoT devices. Use modular systems for easy installation and testing. Monitor system performance and user satisfaction. Analyze the impact on water availability, energy savings, and productivity. Collect community feedback and refine the system for better performance [12]-[18]

1. Problem Identification

Objective: Define the key issues, such as water scarcity, lack of infrastructure, or energy dependency.

Actions: Conduct surveys to assess water availability and quality. Identify communities with limited access to water and electricity. Highlight environmental challenges (e.g., drought, unreliable rainfall).

2. Feasibility Study

Objective: Evaluate technical, economic, and environmental feasibility.

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Actions: Analyze renewable energy potential (e.g., solar intensity, wind patterns). Assess geographical factors for infrastructure mobility. Estimate water demand (household, agricultural, and industrial use). Determine financial viability and potential funding sources.

3. Design and Planning

Objective: Develop a tailored infrastructure model.

Actions: Design modular and portable water supply systems (tanks, pumps, filtration units).

Integrate renewable energy components: Solar panels with inverters and battery storage. Small-scale wind turbines for hybrid energy systems. Plan IoT and smart system integration: Sensors for real-time monitoring of water quality and flow. AI-driven tools for demand forecasting and route optimization. Ensure compliance with local and international standards.

III. RESULTS AND DISCUSSION

Research Location: Errabu Village, Sumenep, Madura, Indonesia Overview of Errabu Village Errabu Village, located in the Sumenep Regency on Madura Island, Indonesia, is known for its rural landscape, agricultural reliance, and growing efforts to integrate renewable energy solutions into its infrastructure. The village is an ideal site for research on renewable energy and smart water systems due to its combination of limited and inconsistent water supply, particularly during dry seasons and abundance of solar energy due to the region's tropical climate. Villagers are often supportive of sustainable solutions that improve their quality of life and economic productivity. Located in a tropical climate with significant solar exposure throughout the year. Primarily an agricultural region relying on seasonal rainfall. Predominantly a farming community with a focus on rice, corn, and livestock. Existing projects include solar-powered street lighting and small-scale solar irrigation pumps. Inconsistent electricity supply in remote areas. Seasonal water scarcity leading to reduced agricultural productivity. High solar irradiance makes it a suitable location for solar-powered systems. Errabu faces challenges in accessing clean and consistent water, making it a relevant site for testing smart water infrastructure solutions. The village has demonstrated openness to renewable energy projects, which can facilitate research and implementation. Insights from Errabu can be scaled to other villages in Sumenep Regency or similar rural settings in Indonesia.

Portable infrastructure for areas lacking permanent water supply systems, such as disaster zones, rural areas, or temporary settlements. Units that can be transported by vehicles, drones, or other mobile platforms. IoT sensors for real-time monitoring of water quality, flow rate, and system efficiency. AI-driven decision-making systems to optimize water distribution based on demand patterns. Solar panels or wind turbines to power the pumps, sensors, and control systems, ensuring operations in remote areas without grid access. Energy storage systems (e.g., batteries) for nighttime or low-energy generation periods. Efficient water filtration and recycling mechanisms to minimize wastage. Reduced reliance on fossil fuels by utilizing clean energy sources. Modular designs that can be scaled up or down depending on population size and water demand. Easy integration with existing water distribution systems. Durable materials and technology designed to operate in extreme weather conditions and challenging terrains. Autonomous systems for self-repair and diagnostics. Rapid deployment in areas affected by natural disasters to provide clean drinking water powered by renewable energy. Serving communities without access to centralized water infrastructure. Delivering water to farmlands in off-grid areas using renewable energy-powered irrigation systems. Enhancing urban water management by integrating smart technologies for efficient water distribution and usage. Providing a sustainable water supply for troops in remote or conflict zones. Portable tanks with smart metering to monitor storage levels. On-demand water purification systems. Foldable or mounted solar panels. Small-scale wind turbines for hybrid energy solutions. Centralized dashboards accessible via mobile apps for operators. AI-powered demand forecasting and anomaly detection. Sensors for pH levels, turbidity, and contamination alerts. Connectivity via 5G, LoRaWAN, or satellite for remote monitoring. Reduces carbon footprint by replacing diesel-powered systems with renewable energy. Lowers operational costs in the long term with reduced reliance on fossil fuels and efficient water usage. Improves water access for underserved populations and critical operations. Capable of operating independently in off-grid or disaster-stricken areas. This concept has transformative potential in tackling global water scarcity, especially in areas where traditional infrastructure is impractical or unsustainable.

Errabu Village Mobile Smart Water Supply Infrastructure Powered by Renewable Energy Overview Errabu Village in Sumenep Regency, Madura, Indonesia, faces challenges related to water scarcity, seasonal variability, and limited access to modern water infrastructure. Implementing a mobile smart water supply infrastructure

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powered by renewable energy can address these issues, offering sustainable, efficient, and adaptive solutions for the community. Proposed System Components

1. Mobile Water Supply Units Design, Portable tanks mounted on trailers or vehicles for mobility. Built-in pumps for water extraction and distribution. Serve remote households, farmlands, or areas affected by seasonal shortages. Adapt to changing demand patterns in different parts of the village.
2. Renewable Energy Sources Solar Power, Solar panels to power water pumps, IoT sensors, and monitoring devices. Energy storage via batteries for nighttime operations. Wind Energy (Optional), Small-scale wind turbines for supplementary energy generation. Hybrid Systems: A combination of solar and wind energy to ensure reliability during varying weather conditions.
3. Smart Technology Integration IoT Sensors, Monitor water quality (pH, turbidity, contamination). Track tank levels, pump status, and distribution metrics. AI and Data Analytics, Predict water demand and optimize distribution routes. Detect anomalies or system failures for quick resolution. Mobile App or Dashboard, Real-time monitoring and control for operators. Notifications for maintenance needs or water delivery schedules.
4. Water Filtration and Treatment, Onboard filtration units for purifying water before distribution. Options for desalination or treating brackish water where necessary.

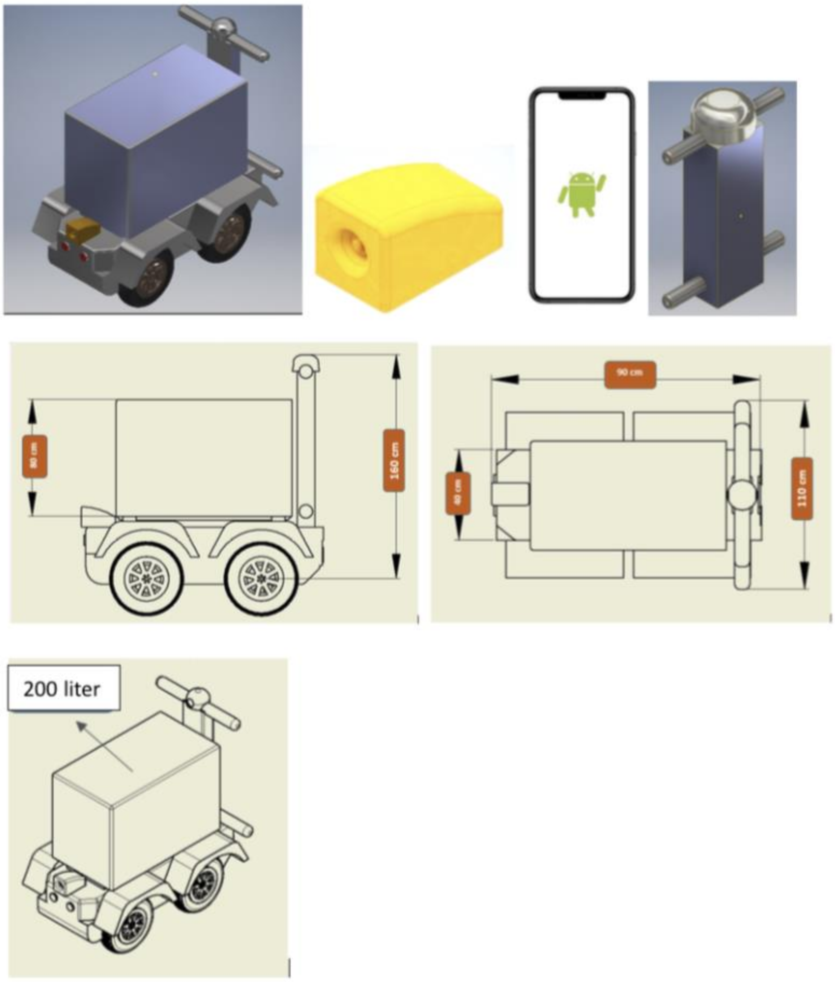

Figure 1. First Design

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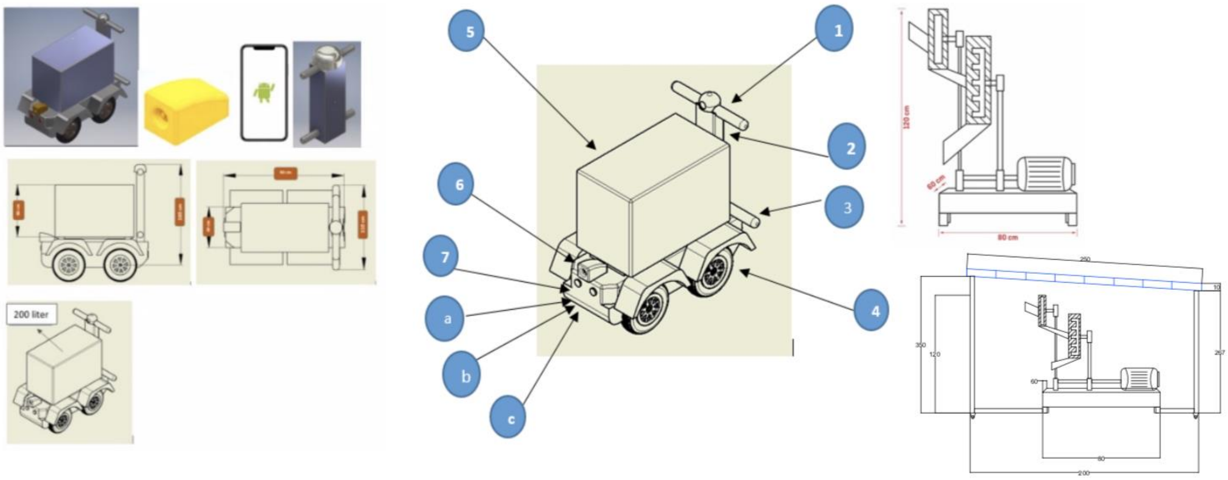

Figure 2. First Design integrated with Agriculture Product Processing

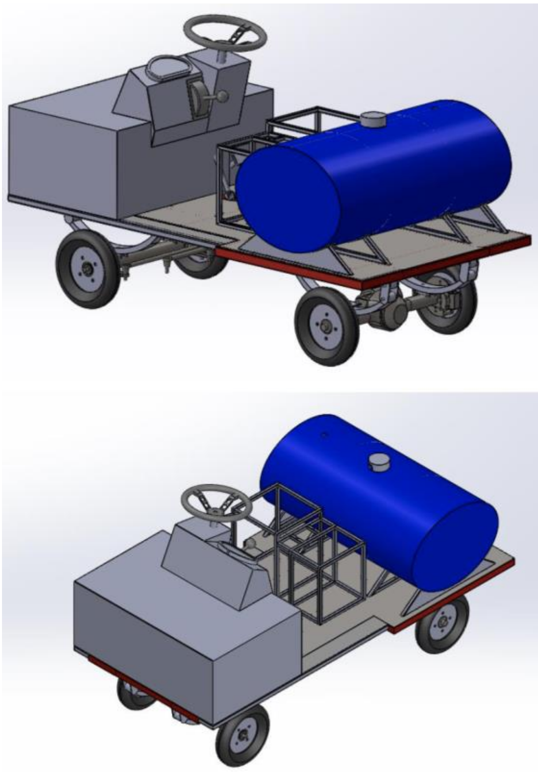

Figure 3. Design Development

IV. CONCLUSION

The mobile smart water supply infrastructure powered by renewable energy in Errabu Village, Sumenep, Madura, Indonesia, aims to enhance agricultural food security. This system integrates smart technology and renewable energy to optimize water resource management and support agriculture in impoverished and underdeveloped areas. Mobile and Smart Concept, allows flexibility in water distribution, enabling access to hard-to-reach areas. Utilizes sensors and IoT devices to monitor and manage water usage efficiently. Renewable Energy, utilizes solarenergy to operate the water supply system, reducing dependence on fossil fuels. Enhances sustainability by reducing carbon emissions and environmental impact. Solutions for Dry Land, employs water-

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saving drip or sprinkler irrigation technology to boost productivity in dry lands. Optimizes water usage for agriculture, thereby increasing yields on previously unproductive land. Food Security, with better access to water, farmers can enhance their agricultural output, contributing to local food security. Enables farmers to grow a variety of crops, increasing food diversity and income. Social and Economic Impact, enhances the capacity of local farmers through training and access to new technologies. By improving agricultural yields, it is expected to reduce poverty levels in the village. Implementation and Collaboration, collaboration between the government, educational institutions, and the community is necessary to design and implement this system. Seeking funding sources from the government or donor agencies to support the development of this infrastructure.

Benefits for Errabu Village, Reduced reliance on diesel-powered pumps. Lower carbon footprint through the use of renewable energy. Mobile units can reach remote areas and adapt to varying seasonal needs. Onboard treatment systems ensure safe drinking water. Lower operating costs compared to traditional water supply methods. Improved agricultural productivity due to reliable irrigation. Ability to respond quickly to emergencies such as droughts or infrastructure failures. Scalable design allows for future expansion as the population grows. Technological Advancement Introducing smart systems fosters technological inclusion and empowers the local community.

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