## Paper 1: Design-and-Development-of-Sun-Tracking-Solar-Panel-with-Implementation-in-Irrigation-System-using-IOT

* Name: Designing and Development of Sun Tracking Solar Panel with its Application in an Irrigation System by use of IOT.
* Authors: Prashant Shrivastava, Pranjal Gupta, Rajneesh Kumar Chaubey, Rachit Jain.
* Year: 2024.
* Issue / Goal: Tackles the irregularities in power supply and the price of fuel used in agricultural scenarios by maximizing the solar power efficiency through motorized trackers and IoT to help generate real-time master control over these systems with a view to achieving sustainability in irrigation without usage of conventional gridded systems.
* • Methodology / System Architecture: Includes the augmentation of motorized solar tracker employing the application of servo motors, under the control of a microprocessor, and light-dependent resistors, the present IoT network of sensors to collect data relating to soil moisture, temperature, humidity, the microcontroller will compute the results to make decisions concerning the irrigation process, the Wi-Fi module will stream data to the cloud, through the GSM module, the system will send SMS notifications in the case of clarity, fault-detecting systems will monitor failure.
* Technologies: Servo motors, microprocessor, Wi-Fi module, GSM module, storage of the data in clouds.
* Sensors (Used): Light-dependent resistors (to obtain sun position), soil moisture sensors, temperature sensors, humidity sensors.
* Communication Protocol: Internet- Wi-Fi- to connect and upload data and GSM- to receive SMS alerts.
* Deployment Environment: Farm fields to automate irrigation, tested in the setting of precision agriculture.
* Results / Performance: Inapplicable (article is on the proposed work and specific related studies, no particular quantitative outcomes of deployment).
* Strengths: Optimises solar energy, real-time monitoring/control, introduces a fail-safe in case of faults, is compatible with sustainable practices.
* Weaknesses: Subject to the accuracy of sensor performances, there may be a problem of internet connections (reduced by GSM but not overcome).
* Future Scope: The future of the topic of precision agriculture and the application of renewable energy.
* **AI/ML Integration**: Not Applicable.
* **Dataset**: Not Applicable.

## Paper 2: Real-time monitoring and data acquisition using LoRa for a remote solar powered oil well

## Title: Monitoring and information acquisition made in real-time of an oil well using LoRa at a distant location using solar-powered energy.

## Onyinyechukwu Chidolue, Tariq Iqbal.

## Year: 2024.

## Problem Addressed / Objective: Eliminates emissions of greenhouse gases of orphaned oil wells allowing remote pumping systems (solar powered) to be monitored in real time even in locations with no available internet connection, cost effective and remotely self-sufficient network to monitor battery voltage, PV current, converter AC, and oil well sensors.

## System Architecture / Methodology: The wireless communication is over LoRa, the sender node (TTGO LoRa32 SX1276 OLED) is the transmitter of the sensor data, the receiver node (Heltec LoRa ESP32) can serve as gateway to the cloud, the working/shutdown pattern is defined periodically according to a power-saving schedule, data measurement is via PLX-DAQ to record data.

## Technologies: TTGO LoRa32 SX1276 OLED (sender), Heltec LoRa ESP32 (receiver), Raspberry Pi as a gateway, the Arduino IDE to create the software, the Wi-Fi to access the web server.

## The used sensors: PV voltage/current sensors, inverter AC output sensor, oil level sensor, temperature sensor, relative humidity sensor.

## Communication Protocol: LoRa to long-range Wireless transmission, Wi-Fi: to cloud gateway.

## Deployment Environment: Far oil well locations that may not have an internet connection, tested using solar powered pumps.

## Results / Performance: Revealed real time data capture, very low power consumption, which would suit application where the device would operate with battery, data is available even on a remote basis through clouds.

## Advantages: Affordable, does not require the internet, has distance coverage (attains long distances), it has low power consumption, is applicable in remote regions and low-network regions.

## Limitations: No real-time power monitoring because it operates periodically, requires the web server, may have limitation in multi-hop networks.

## Future Scope: Scheme nodes per relay, combine with additional sensors to expand scopes of use.

## AI/ML Integration: NA.

## Dataset: Not Applicable (relies on real-time sensor data, there is no dataset that already exists).

## Paper 3: Design and Development of Solar Powered IoT

## Name: Design and Development of Solar Powered IoT Enabled Multi-layer Soil Moisture Probe.

## The authorsâ€ traicate: Sarowar Morshed Shawon, Md. Ziad Kabir, Asadur Noor Adnan, Arindom Chakraborty, Kazi Md Shawal Noor.

## Year: 2025.

## Problem being Addressed / Objective: Solves the problem of underdeveloped agricultural sector by virtue of lacking technology integration, a paradigm shift is to take place in farming through the process of soil moisture monitoring at various depths (30-180 cm) as well as temperature of soil in order to determine crop water requirements with great accuracy enabling greater efficiency and sustainability in farming.

## System Architecture / Methodology: Multi-layer probe including 5 soil moisture sensors and 3 temperature sensors, ESP8266 to enable IoT communications, data sent to smartphone app, solar powered to be sustainable.

## Technologies Applied: ESP8266, application (app) on the smartphone to visualize the data, solar power.

## The Sensor Types: 5 soil moisture sensors (at measurements at varying depths), 3 temperature sensors (at the depths of 50-150 cm).

## Communication Protocol: Connectivity of IoT using ESP8266 (wireless to app).

## Deployment Situation: Local agricultural field, applicable to rooftop agriculture or field.

## Performance / Results: Preliminary testing shows that product is reliable, efficient and accurate system, monitors multi-layer moisture/temperature in real-time.

## Strengths: Rootzone accuracy through multi-layers sensing, solar powered, real time monitoring app, maximizes water used.

## Limitations: Has no automatic irrigation, only focused on monitoring.

## Possible Future Direction: Include automatic irrigation: widen to additional parameters.

## Integration of AI/ML: NA.

## Dataset: Not available (There is an application of real-time sensor data).

## Paper 4: Performance of an internet of things based plant monitoring and irrigation system using solar energy

## Title: Performance of a solar energy based plant monitoring and irrigation system with an internet of things.

## Md Azim Affzani Md Rozani, Khalil Azha Mohd Annuar, Mohd Razali Mohamad Sapiee, Sanjoy Kumar Debnath.

## Year: 2025.

## Problem to be Solved / Purpose: Eliminates lack of efficiency in water/energy usage associated with traditional irrigation, to empower real-time monitoring/ or control of soil moisture/temperature/humidity using IoT, sustainably by solar energy.

## System Architecture / Methodology: incorporates sensors, NodeMCU ESP32 microcontroller, water pump, solar panel charges power bank, the Blynk platform to check remotely/control, automatic irrigation above threshold.

## The technologies: NodeMCU ESP32, Blynk app, PV panel, water-level ultrasonic sensor.

## Soil moisture sensor, DHT22 (temperature/humidity), ultrasonic sensor (water level).

## Communication SCP: NodeMCU ESP32 to Blynk cloud (Wi-Fi ).

## Deployment Environment: Plant trays during the experiment setup, plant in gardens and farms.

## Outputs / Results: Accuracy of temperature sensor 98%, humidity 95%, soil moisture error 2-3%, growth of the plant under improved 7-8% compared to conventional systems.

## Positives: Renewable solar energy, programmable, accurate watering, environment friendly.

## Weaknesses: Dependent upon solar irradiance (must use backup wall charger), can only be used in large-scale or abandoned wells.

## Future Scope: Tailor to be used in off-grid regions, ad more sensors.

## AI / ML Integration: NA.

## Dataset: NA.

## Paper 5: Botanika: Soil profiling sensor probe enabled by IoT and solar powered to farm on rooftops.

## Name: Botanika: Soil profiling sensor probe enabled by IoT and solar powered to farm on rooftops.

## Jui, Anjuman Naher, Dey, Nabonita, Kazy Noor-E-Alam Siddiquee, Sarowar Morshed Shawon.

## Year: 2024.

## Problem Addressed / Objective: Solves urban agriculture problem of limited space/time, it aims to observe soil parameters (moisture, temperature, humidity and rainfall) in rooftop gardens so as to optimise growing of the plants through in-situ calibration and remote sensing.

## System Architecture / Methodology: Self developed soil scouting probe with sensors, NodeMCU as data acquisition system, Android app for monitoring, solar.

## Technologies: NodeMCU, android app, solar power.

## Sensors Composed: moisture soil sensor, soil temperature sensor, temperature sensor, humidity sensor, rainfall sensor.

## Comm Protocol: IoT using NodeMCU (wireless to app).

## Deployment Environment: Rooftop farming in cities such as in Bangladesh.

## Outcomes / Benchmarking: Correct data gathering, increases the crop wellbeing/yield in urban environments.

## Strengths: It is cost effective, solar powered, easy to use app, it encourages green urban agriculture.

## Limitations: Depends on man's watering, dynamics of soil depending upon types/textures.

## Future Scope: To combine with water management, to work in other environments.

## AI/ML Incorporation: NA.

## Dataset: NA.

## Paper 6: Solar Power IoT Based Smart Agriculture System

## Name: Solar Power IoT Based Smart Agriculture System Using NodeMCU ESP32.

## Authors: Nur Khairiah Mohd Khalid, Norezmi Jamal, Farahiyah Mustafa, Group torno Aira Zambri, Mohamad Syah Rizal Abdullah.

## Year: 2024.

## Objective: This is a solution to the global food shortage as a result of climate change, the project will come up with an IoT solar-generating system that will monitor/control the temperature, humidity, and soil moisture levels in the greenhouse in order to support optimal crop growth.

## System Architecture / Methodology: NodeMCU ESP32 reads data, acts on sensor data, sends data to Blynk app and Google Sheets using IFTTT, lights and pump turned on automatically once a threshold is reached, battery powered by solar panel.

## Technologies: NodeMCU ESP32, Blynk app, Google Sheets / IFTTT, solar panel.

## The sensors deployed: DHT11 (temperature/humidity), soil moisture sensor.

## Communication Protocol: The Wi-Fi is through ESP32, IFTTT is JSON payload.

## Deployment Environment: Chili Plant green house, lab configuration.

## Performance / Results: High ranking in correlation with Weather Underground, tough solar system, real time feedback.

## Advantages: Lowers expenses/human error, alternative energy, ability to access them in near real- time.

## Limitations: Applicable only to a specific plants (chili), experimental.

## Future Scope: Fill the data gaps, Performance tune-up.

## AI/ML Integration: NA.

## Dataset: interval dataset of 15-minute intervals of sensors, compared with Weather Underground

## Paper 7: Optimising performances of LoRa based IoT enabled wireless sensor network for smart agriculture

## Title: Optimisation of LoRa based IoT enabled wireless sensor network to be used in smart agriculture.

## First Author: Yik-Tian Ting. Second Author: Kah-Yoong Chan.

## Year: 2024.

## Problem Addressed / Objective: Delves into food security in regions that depend on imports including Malaysia, maximizes LoRa IoT with its cost-effective smart farming use in small farm areas, and targets productivity without the need of expensive solutions.

## Methodology / System Architecture: LoRa enabled sensors sending data to thingspeak cloud through gateway, optimisation of variables such as frequency, distance, environment, quantitative extraction of data regarding influencing factors on performance.

## Technologies: LoRa moduls, IoT Thingspeak platform, monitoring/control sensors.

## Sensors: Various crop cultivation sensors e.g., soil, environmental.

## Communication Protocol: LoRa (CSS modulation), to cloud.

## Deployment Environment: fruit/vegetable farms, tested with varying weather/conditions.

## Results / performance: Extensive (p < 0.05) effects of LoRa frequency, distance, environment, weather on performance, efficient in small-scale farms.

## Advantages: Inexpensive, long range, Low-power, Low-power, Scalable to small farms.

## Drawbacks: Exclusively narrow regions, the possibility of duplication of features.

## Future Scope: Faster scaling/UI, add advanced features such as AI, environmentally friendly solutions.

## Integration of AI/ML: Not Applicable (refers to the prospects of future ML).

## Dataset: real time close proximity sensor data, no prior existing dataset.

## Paper 8: Implementation and Evaluation of a Low-Cost Measurement Platform over LoRa and Applicability for Soil Monitoring

## Title: Deployment and Testing of a Low-Cost Measurement system in LoRa and Usability as Soil Sensor.

## Researchers: Dimitrios Loukatos, Athanasios Fragkos, George Kargas and Konstantinos G. Arvanitis.

## Year: 2024.

## Problem Addressed / Objective: Provides low cost/cost effective soil monitoring, Creates low-cost LoRa-based product, to monitor soil data (moisture, conductivity) in real time with energy autonomy, to enable sustainable agriculture.

## Methodology / System Architecture: microprocessor + LoRa transceiver, sensors embedded in the nodes as soil monitors, sleep modes when there is no activity, solar panels to be used to capture data, transmitted via LoRa.

## Technologies Used: LoRa radio, mini solar panels, open-source parts.

## The Sensors: TEROS 10/ TEROS 12/ 5TE/ 10HS/ ThetaProbe ML2 (soil moisture/conductivity/temperature).

## Protocol: LoRa rural long-range.

## Deployment Environment: Cultivated crops, this has been tested using the different soil tools in different conditions.

## Results / Performance: High-quality data measuring satisfactory corridors, quota coverage / consumption / quality by solar, viable.

## Advantages: Low cost, energy efficient, capable of supporting a variety of different sensors, can be deployed unattended in long term monitoring.

## Limitations: Sensor interfacing: heterogeneity, exposure to different treatment environments.

## Future Scope: Add on more sensors, make more multidisciplinary.

## AI/ML Integration: N/A.

## Data set: Real time data related to Soil Measured by sensors.

## Paper 9: LoRa\_Communication\_for\_Agriculture\_40\_Opportunitie

## Summary: LoRa Communication to Agriculture 4.0: Opportunities, Challenges and Future Directions.

## Lameya Aldhaheri, Noor Alshehhi, Irfana Ilyas Jameela Manzil, Ruhul Amin Khalil, Shumaila Javaid, Nasir Saeed, Mohamed-Slim Alouini.

## Year: 2024.

## Research Topic / Problem of Interest: Investigates LoRa as IoT solution to smart agriculture, will map possibilities/constraints in long-range ag-related communication to help efficiency/sustainability.

## Methodology / System Architecture: Surveys LoRa networks: architecture (PHY, channel modeling of soil), relaying/routing to provide coverage, deployment and sensor power management.

## Technologies, Used: LoRa/LoRaWAN, CSS modulation, comparisons with ZigBee, Bluetooth, Sigfox, WiFi.

## Sensors: NA (review paper, does discuss general sensors in other relevant areas of irrigation/soil/pesticides).

## Communication Definition/Standard: LoRa (SF to trade-off coverage/data rate), LoRaWAN.

## Deployment Environment: Greenhouse, farmlands, normal agricultural land(s), subjected to testing in different studies.

## Performance / Results: LoRa Long range/low power, does well in pest detection/greenhouses.

## Strengths: Long range, low powered, secure, flexible to agriculture.

## Disadvantages: Interference / noise, obstruction via distance, low data rate.

## Future Scope: Incorporate AI/ML, new routing, hyper-spectral/drone sensor, green solutions.

## AI/ML Integration: Recommends AI model at the device level, reinforcement learning to make decisions.

## Dataset: Not Applicable (review, uses data of several studies).

## Paper 10: A Self-Powered, Real-Time, LoRaWAN IoT-based

* Title: Self-Powered, real-time, LoRaWAN-based IoT-based Soil health monitoring system.
* Authors: S.R. Jino Ramson, Walter D. Le n-Salas, Zachary Brecheisen, Erika J. Foster, Cliff T. Johnston, Darrell G. Schulze, Timothy Filley, Rahim Rahimi, Mart n J. C. Villalta Soto, Juan A. Lopa Bolivar, Mauricio Postigo M laga.
* Year: 2021.
* Problem Addressed / Objective: Solves expensive/time-consuming soil health checking, proves solar powered IoT system to keep track of soil temperature/moisture/EC/CO2 in real-time.
* Methodology / System Architecture: Size Sensors attached to Soil Health Monitoring Units (SHMUs), LoRaWANs to transmit, servers/dashboard via gateway, battery Li-ion, solar will charge it.
* Technologies: LoRaWAN radio, Web dashboard, solar panel (7 cm 6.5 cm).
* Sensors: Soil Temperature/Moisture/EC, CO2, geo-location.
* Communication Standard: LoRaWAN.
* Deployment Conditions: Farm field locations, installed and operated with 8 SHMUs weeks.
* Performance / Results: Transmission range 3422 m, current drain 13 mA ( operating days) solar panel takes 14 days to fully charge, 30 percent water savings during tests.
* Strengths: powered by itself, real time, cheap, flexible (additional CO2 sensor).
* Weaknesses: Low quality sensors are costly, poor resolution(spatial/temporal) of labs.
* Future Scope: Add more metrics to integrate, increase more deployments.
* Integration of AI/ML: No.
* Dataset: Field sensor data real time.

## Paper 11: LoRa-based Data Communication, Acquisition, and Visualization System for Real-time Monitoring of Soil Parameters

* Title: Data Communication, acquisition and visualization System built with LoRa
* Instant detection of the Soil Parameters
* Editors: Maheshwar Durgam, Damodhara Rao Mailapalli, Rajendra Singh
* Year: 2025
* Problem addressed / Objective: Mitigates time consuming and expensive traditional monitoring techniques of soils, creates a wireless sensor network (ArLoRa-Ag) based on LoRa, to monitor the soil moisture and temperature in real-time so as to optimally cultivate crops productivity.
* Methodology / System Architecture: ArLoRa-Ag system is based on use of Arduino, LoRa,
* and Raspberry Pi to communicate the data, accuracy of sensors tuned, visualised using a web application written in JavaScript (AgDaMo) and evaluated limitations and range of data loss.
* semi-urban/ agricultural settings.
* Technologies: Arduino, LoRa modules, Raspberry Pi, JavaScript based AgDaMo web tool to visualize.
* Sensors: Soil moisture sensor (capacitance-based, soil temperature sensor (DS18B20 thermistor-based).
* Communication Protocol: LoRa with a long wireless range communication protocol.
* Deployment Environment: in the fields and semi-urban terrain, tested to produce range and precision.
* Findings / Performance: Calibration of sensors showed an R2 0.999 (temperature) and 0.993[moisture], field calibration using R2 of 0.935, RMSE 0.607 o C, MAE 0.369 o C in respect to temperature, R2 of 0.929, RMSE 1.049%, MAE 0.875% in respect of moisture, 500 m propagation distance (obstructed/maximum by features such as trees/buildings).
* Strengths: Inexpensive, proper calibration of sensors, visualization in real-time, appropriate, so that they can be remotely monitored.
* Restrictions: The distance through which it is transmitted is not difficult due to the obstruction, loss of data can cause problems where the transmission signal is too complex environments.
* Future Scope: Increase range and robustness, add other sensors to expand capability, design in wireless communications capability, internalize wireless sensor capability into the monitoring unit, foresee the need to replace the barcode tag with an RFID type that will be compatible with large scale adoption across industries, thought will have to be given to how to store the historical data on this identification tag, or perhaps other sensors will store it, the thought that needs to be given is how to keep the historical data safe, have a feature of being able to access historical data, will have to consider how to ensure existing barcode tags become compatible with an observation of soil parameters.
* AI/ML Integration:Not Applicable.
* Dataset: Live field tests sensor data, no available data.

## Paper 12: Solar Power IoT Based Smart Agriculture System Using NodeMCU ESP32

• Title: Solar Power IoT Based Smart Agriculture System Using NodeMCU ESP32

• Authors: Nur Khairiah Mohd Khalid, Norezmi Jamal, Farahiyah Mustafa, Nor Aira

Zambri, Mohamad Syah Rizal Abdullah

• Year: 2024

• Problem Addressed / Objective: Addresses global food shortage due to climate

change; aims to develop a solar-powered IoT system for greenhouse monitoring/control

of temperature, humidity, and soil moisture for optimal crop growth, specifically for

chili plants.

• Methodology / System Architecture: NodeMCU ESP32 processes data from sensors; transmits to Blynk app and Google Sheets via IFTTT; automatic control of water

pump/fan based on thresholds; solar panel converts sunlight to DC power stored in

batteries, managed by a charge controller.

• Technologies Used: NodeMCU ESP32; Blynk app; Google Sheets/IFTTT; solar

panel; charge controller.

• Sensors Used: DHT11 (temperature/humidity), soil moisture sensor.

• Communication Protocol: Wi-Fi via ESP32; JSON payload to IFTTT for Google

Sheets integration.

• Deployment Environment: Greenhouse for chili plants; experimental setup.

• Results / Performance: High correlation with Weather Underground data for temperature and humidity; resilient solar system; real-time visualization via Blynk and Google Sheets; 15-minute interval data collection.

• Strengths: Reduces costs and human error; renewable energy; real-time app access;

automated control.

• Limitations: Limited to specific crops (chili); experimental scale; potential data gaps

in soil moisture.

• Future Scope: Address data gaps; optimize performance for broader crop types.

• AI/ML Integration: Not Applicable.

• Dataset: 15-minute interval dataset from sensors; compared to Weather Underground

data.