Project Title: Evapotranspiration (ET)-Based Irrigation System with Internet of Things (IoT) Integration for Smart Farming Application Addressing the ASEAN Impending Water Crisis

Background :

With the growing interest in the field of Information and Communications Technology (ICT) particularly in the area of Internet of Things and sensor technology a lot of studies are being done in Precision Agriculture/Smart Agriculture. With this, we can incorporate and integrate this concepts and technology to develop a mechanism for smart irrigation/precision irrigation. Precision irrigation maybe a vital exercise in water-saving agriculture cropping system which let farmers conserve water without sacrificing its productivity. It will give farmers the capability of knowing beforehand the amount of water loss in the land and become the basis for irrigation.

Targets:

The methodology for this project are enumerated with the following major activities:

- **Crops Irrigation Requirement Profiling**
- **Design of ET-Based Irrigation Scheduling Controller**
  - **Hardware Design Considerations and Testing**
  - **Software Design Considerations and Testing**
- **IoT Integration**
- **System Implementation, Experimentation and Verification**

Speaker:	Dr. Jennifer Dela Cruz

Project Title: Evapotranspiration (ET)-Based Irrigation System with Internet of Things (IoT) Integration for Smart Farming Application Addressing the ASEAN Impending Water Crisis

Project Members :

Name	Position/Degree	Department, Institution, Country	Email Address
Meo Vincent C. Caya	Senior Researcher PhD Candidate	MU, Philippines	mvccaya@mapua.edu.ph
Febus Reidj Cruz	Senior Researcher PhD Candidate	MU, Philippines	frgcruz@mapua.edu.ph
Joseph Bryan Ibarra	Senior Researcher	MU, Philippines	jbgibarra@mapua.edu.ph
Dr. Ireneo C. Agulto (retired)	Dean, College of Engineering	CLSU, Philippines	ireneoagulto@yahoo.com
Adrian Chummac	Senior Researcher	CLSU, Philippines	chummacadrian@gmail.com
Dr Sevia M. Idrus	Professor, Department Of Communication Engineering	UTM, Malaysia	sevia@utm.my
Dr Muhammad Al FarabiMuhammad Iqbal	Senior Lecturer, Department Of Communication Engineering	UTM, Malaysia	alfarabi@utm.my
Dr Nadiatulhuda Zulkifli	Senior Lecturer, Department Of Communication Engineering	UTM, Malaysia	nadiatulhuda@utm.my
Dr. Khin Than Mya	Head of Embedded System Lab./ Associate Prof./ Ph.D	UCSY, Myanmar	khinthanmya@gmail.com
Eiji Kawai	Head of Research on Testbed R&D Promotion	NICT, Japan	eiji-ka@jgn-x.jp

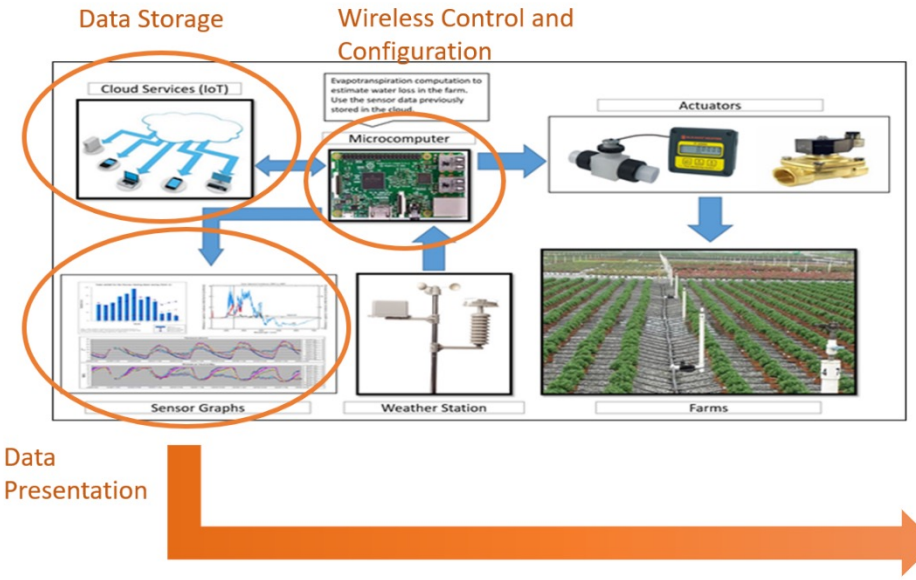
Project Duration : 3 Years

Project Budget: $47,570 USD

Project Activities:

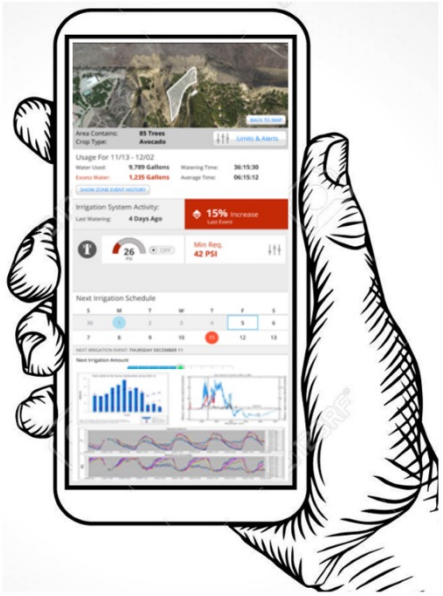
Project Objectives:

- Evaluate the suitability of evapotranspiration (ET)-based irrigation scheduling technologies for agricultural applications, specifically, the ability to: apply the appropriate amount of water at the appropriate time, using the estimated reference ET (ETo) in a particular field.
- IoT Integration



The Mobile App can have:

- Monitoring data presentation can be provided by the Cloud or the Wireless Connection (if within range)
- Wireless Update can only be done on site.
- Wireless Configuration and control can be done on-site



Project Activities: Site Visits and Meetings, MU and CLSU (Nov 13-14, 2020)

*Recalibration of plan due to typhoon devastation of the site

* We were given another nearby site by the new Dean of CLSU, however, due to distance between AWS and irrigation system, an RF system must be set up to make them communicate

Visit to CLSU Lab

Project Activities:

- **Installation of AWS in CLSU and MU**




Collected 6-hourly weather data from CLSU PAGASA Synoptic/Agrometeorological Weather Station for the month of November to December 2019 to be used to evaluate the accuracy of the installed weather sensors.

Drip Irrigation System and Field Trial


Pump


Pressurized Tank


Drip laterals and drip tape


Solenoid valve installation


Installation of drip lateral


Installation of drip tape


Experimental area with drip irrigation system


Corn Planting


Crop 10 DAP


Crop 15 DAP


Crop 20 DAP


Crop 30 DAP


Flowering

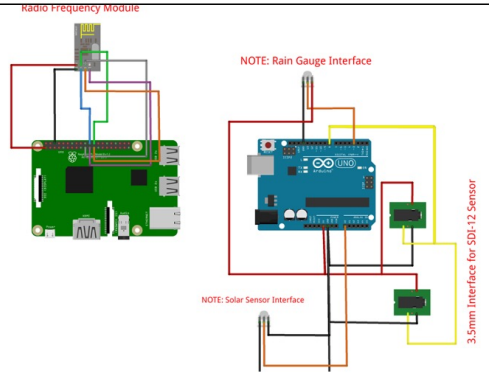

Crop 60 DAP

DAP – Days after planting

Project Activities:

a. Field trial of AWS Data Transmission via RF

b. RF Module and setup



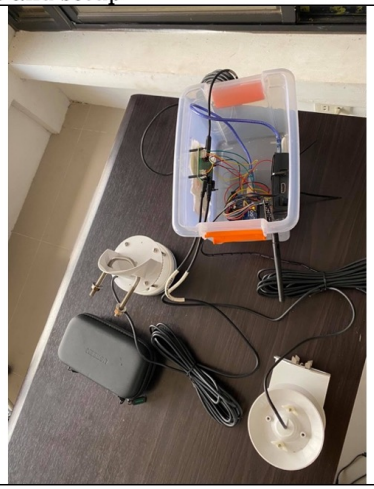
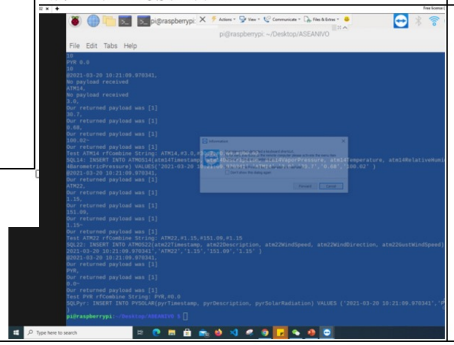


Fig 10. AWS and RF Module

a. Data Acquisition Test

b. RF Test Run



c. AWS Data

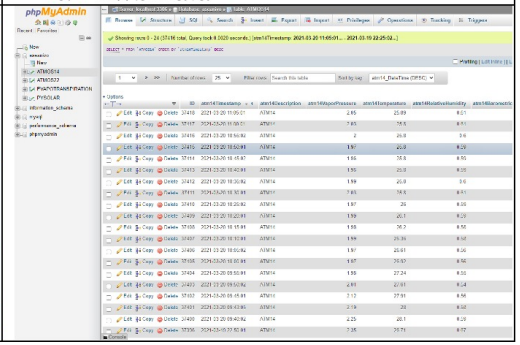


Figure 11. RF Data Transfer

R&D results: **Mapua University**

Evapotranspiration-Based for Crop Cultivation with Deficit Irrigation Scheme

Abstract: Most of the crops in agriculture requires a sustainable supply of water for their growth and maturity. Thus, an efficient, and practical irrigation method is needed to maintain the water requirement of a plant. This study aims to develop an irrigation system with a deficit irrigation scheme and determine the effects on the plants of applying the deficit irrigation. The height and the fruit yield of the fully watered plant were compared to the reduced amount of water such as 50% and 75%. By using the t-test formula statistics, the research had stated that reducing the amount of water to the plant can still sustain and live. Using the Penman-Monteith equation, the system-imposed deficit irrigation water supply of 100% 〖ET〗 _C, 75% 〖ET〗 _C and 50% 〖ET〗 _C crop water requirement based on crop evapotranspiration. The researchers were able to develop an irrigation system using evapotranspiration into a "Solanum Melongena" plant that can control the amount of water to be dispensed to the plant on a specific deficit scheme. The system can control the water need to dispense according to the predefined deficit scheme.

International Conference: HNICEM 2020 (Under Review)

Authors: Meo Vincent Caya; Jennifer dela Cruz; Jannie Mae M. Villareal; Reth Jeron H. Yang

ASEAN-IVO Member: Meo Vincent Caya and Jennifer dela Cruz (Technical Supervision and Guide; Conceptualization; Methodology)

R&D results: **Mapua University**

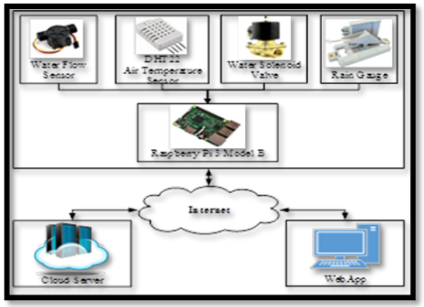
Development of Evapotranspiration-based Irrigation System using Hargreaves-Samani Equation for Public Park Application

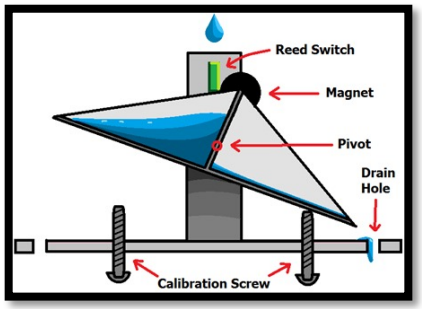
Abstract: Different methods in water saving are applied to maintain the landscapes and reduce the amount of water needed to be irrigated in public parks. Scheduled watering is the most common type of method used by public parks, in which estimating the amount of water leads to over or under irrigation. Irrigation systems that uses evapotranspiration as a parameter in controlling the amount of water to irrigate on public parks are not found in the Philippines. Evapotranspiration is the rate of water lost from plants and soil through evaporation and transpiration within a specific area. This study focuses on the development of a device that would be used for the monitoring of evapotranspiration using the Hargreaves-Samani Equation. This would include the calibration of sensors and development of device used such as the DHT22 Humidity and Temperature sensor, Water Flow sensors and Tipping Bucket Rain Gauge. Furthermore, a Stevenson screen is created to provide the sensors protection from harsh weather conditions and provide proper ventilation. After testing the prototype, the results obtained from the sensors provided an average percent difference of less than 5%, indicating that the prototype is functioning properly.

International Conference: HNICEM 2020 (Under Review)

Authors: Meo Vincent C. Caya; Ryan L. Gosiaco; Daniel Jaezon D. Sablay; Immanuel Robert D. Sioson

ASEAN-IVO Member: Meo Vincent Caya (Technical Supervision and Guide; Conceptualization; Methodology)





R&D results: **Universiti of Teknologi Malaysia**

Evapotranspiration (ET)-Based Irrigation System with Internet of Things (IoT) Integration for *Capsicum Annuum*

Abstract: This paper presents a methodology to develop an irrigation system that determines the amount of water to be provided based on water loss due to evapotranspiration (ET) process. The computed amount of water was based on the data gathered from an automatic weather station (AWS) sensor suites installed in the plantation plot. Capsicum Annuum or commonly known as Chili is the crop of interest in the conducted study due to its popularity amongst Malaysians. The system comprises microcontroller with the integration of sensors, actuator and valve modules where each node serves as an IoT device. The environmental parameters are being monitored directly over the AWS console and remotely over mobile application that helps in the controls of each node and configuration settings for irrigation. The computed amount of water for irrigation is based on CIMIS Modified Penman model for the computation of the daily reference ET, ETo. Compared to the conventional irrigation method, it is anticipated that the proposed irrigation model would help in reducing water usage without compromising its produce.

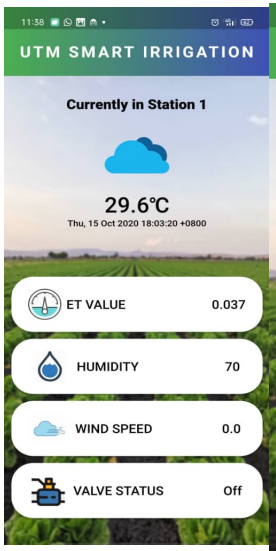
International Conference: 2020 IEEE International Symposium on Telecommunication Technologies (ISTT2020) November 9-11, 2020

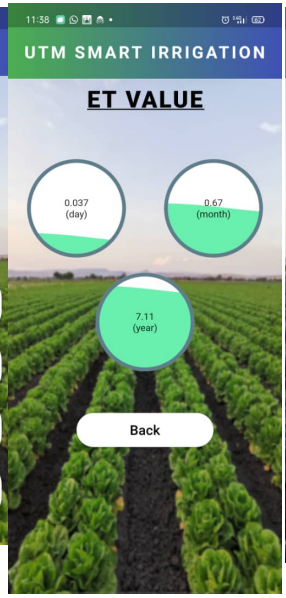
Authors: Nadiatulhuda Zulkifli , Raja Zahilah Raja Mohd Radzi, Farabi Iqbal, Arnidza Ramli, Sevia M Idrus
Jennifer Dela Cruz, Ireneo Agulto and Meo Vincent Caya

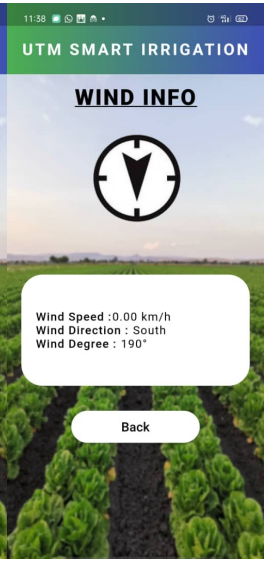
ASEAN-IVO Member: All authors

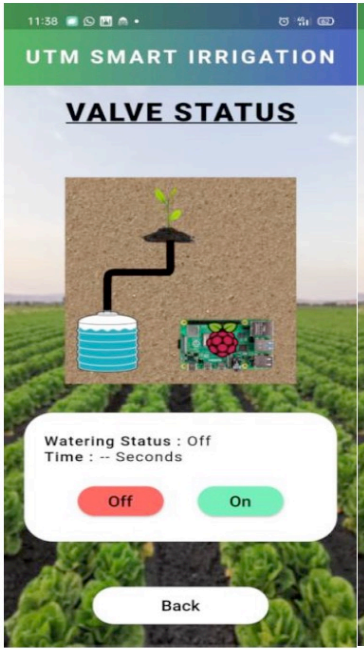
Mobile App Interfaces

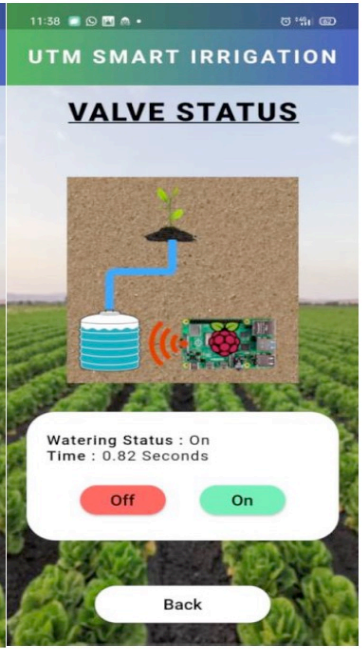
a. Main Page of Smart Irrigation App – This main page shows a summary of important information such as station's name, cloud condition, temperature, ET value, humidity, wind speed and valve status.











R&D results :

Presentations at International Conferences:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1	Integration of Water Control with a Drip Irrigation System for Agricultural Application	Meo Vincent C. Caya; Adrian G. Narciso; Mariah Camille A. Roque; Wen-Yaw Chung	Mapua University, Philippines CYCU Taiwan	2019 IEEE HNICEM	Nov 28-Dec1, 2019	Fort Ilocandia, Laoag Ilocos Norte, Philippines
2	Development of ET-Based Irrigation System in Green Roofs Using Penman-Monteith Equation	Meo Vincent Caya; Jennifer Dela Cruz; Juan Paolo M. Merina; Daryl Kiel H. Mora; Sarah Alma P. Bentir	Mapua University, Philippines	2019 IEEE HNICEM	Nov 28-Dec1, 2019	Fort Ilocandia, Laoag Ilocos Norte, Philippines
3	ET-Based Smart Irrigation System with irrigation postponement Algorithm for Lycopersicon Esculentum or Tomato plant	Meo Vincent Caya; Alejandro Ballado Jr.; Eliza Marie C. Rabino; Carl Anthony H. Delim	Mapua University, Philippines	2019 IEEE HNICEM	Nov 28-Dec1, 2019	Fort Ilocandia, Laoag Ilocos Norte, Philippines
4	Evapotranspiration-Based for Crop Cultivation With Deficit Irrigation Scheme,	Meo Vincent C. Caya; Jennifer Dela Cruz;M. Villareal; Wen-Yaw Chung	Mapua University, Philippines	2020 IEEE HNICEM	Dec 28-29,2020	Virtual/Philippines
5	Greenroof Irrigation Using Evapotranspiration for Alfalfa and Basil	Jennifer Dela Cruz; Meo Vincent Caya; Adrian Chummac et al.	MU, CLSU	2020 IEEE HNICEM	Dec 28-29,2020	Virtual/Philippines
6	Development of Evapotranspiration-Based Irrigation System Using Hargreaves-Samani Equation for Public Park Application	Meo Vincent C. Caya; Jennifer Dela Cruz;M. Villareal; Wen-Yaw Chung	Mapua University, Philippines	2020 IEEE HNICEM	Dec 28-29,2020	Virtual/Philippines
7	Evapotranspiration (ET)-Based Irrigation System with Internet of Things (IoT) Integration for Capsicum Annuum Farming: A Methodology,"	N. Zulkifli et al..Meo Vincent C. Caya; Jennifer Dela Cruz;	UTM; Mapua University, CLSU	2020 IEEE ISTT	2019	Malaysia
8	Evapotranspiration-based Irrigation System for Mustard Green Crop Cultivation using Public Weather Forecast	Jennifer Dela Cruz; Meo Vincent Caya; Adrian Chummac et al.	MU, CLSU	2021 IEEE ICSGRC	Jul-21	Virtual/Malaysia

Leveraged Resources and Participants

There are several reasons for the collaborations in this project, including

1. Irrigation systems are standard for all crop cultivation; it will be vital to share the knowledge and experience in implementing an ET-Based irrigation scheme to have an alternative and much efficient way to use water for irrigation
2. To share the technology and transfer the knowledge for a better irrigation scheme.
3. Conduct Field demonstrations for proof of concept to show that the ET-based irrigation system works.
4. To promote the developed technologies through publications and research to the academe, industry, and farming irrigation in other countries.

The collaboration between the institutes helped enhance the technical and social impacts of the project. The detail of each member's contribution is described as follows

(1) School of Electrical, Electronics and Computer Engineering, Mapua University: collaboration of overall technical and detail system configuration including all the components and equipment needed.
(2) College of Engineering, Central Luzon State University (CLSU) – Collaboration related to irrigation engineering and ET value calculation.
(3) Faculty of Engineering, UTM – Hardware experimental setup, software development and Mobile App development

Findings and Outcomes

In this project, we have developed and achieved significant outcomes that can have high impact on the technology development and application in the fields of ET-Based irrigation. The significant findings and outcomes are summarized as follows,

The project provides a step-by-step procedure in the determining the crop coefficient which is a vital information for the computation of the Crop Evapotranspiration (ETc)

The implementation of the ET-Based Irrigation system in agriculture may have a 60%-70% decrease in water consumption as compare with the conventional way of irrigation It can be an efficient alternative for Agricultural irrigation.
The ET-Based irrigation system can be implemented in an urban setting. It can be implemented in the irrigation system of public parks.
The ET-Based Irrigation technology was also implemented together with the deficit irrigation scheme and the results shows a further water savings can be achieved.

Future works:

The project has encouraging results, and the ET-Based Irrigation technology, although not new, is still not utilized or implemented, particularly in the Philippines. It may significantly impact the efficient use of irrigation water in rural or urban parts of the country. We are considering the integration and implementation of the developed ET-Based Irrigation Technology in an urban setting. The figure below shows the future implementation of the project.

We will also explore other irrigation regimes. Instead of applying irrigation daily, maybe we can adjust it every two days, three days, or even a week as long as the crop will not experience a water deficit. This is to improve the application efficiency of the irrigation system since daily application corresponds to daily losses. In contrast, we can reduce the application losses when you irrigate at more than a 1-day interval. Also, we will explore the integration of rainfall forecasts into the system using machine learning or other statistical analysis. This is to apply the irrigation precisely and avoid wasting water when applying irrigation.

Future Developments:

This figure shows the future implementation of the project.