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 (IoT) and sensor technology a lot of studies are being done in Precision Agriculture/Smart Agriculture. With this, we can incorporate and integrate these concepts and technology to develop a mechanism for smart /precision irrigation.

Precision irrigation maybe a vital exercise in w

ater-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 :

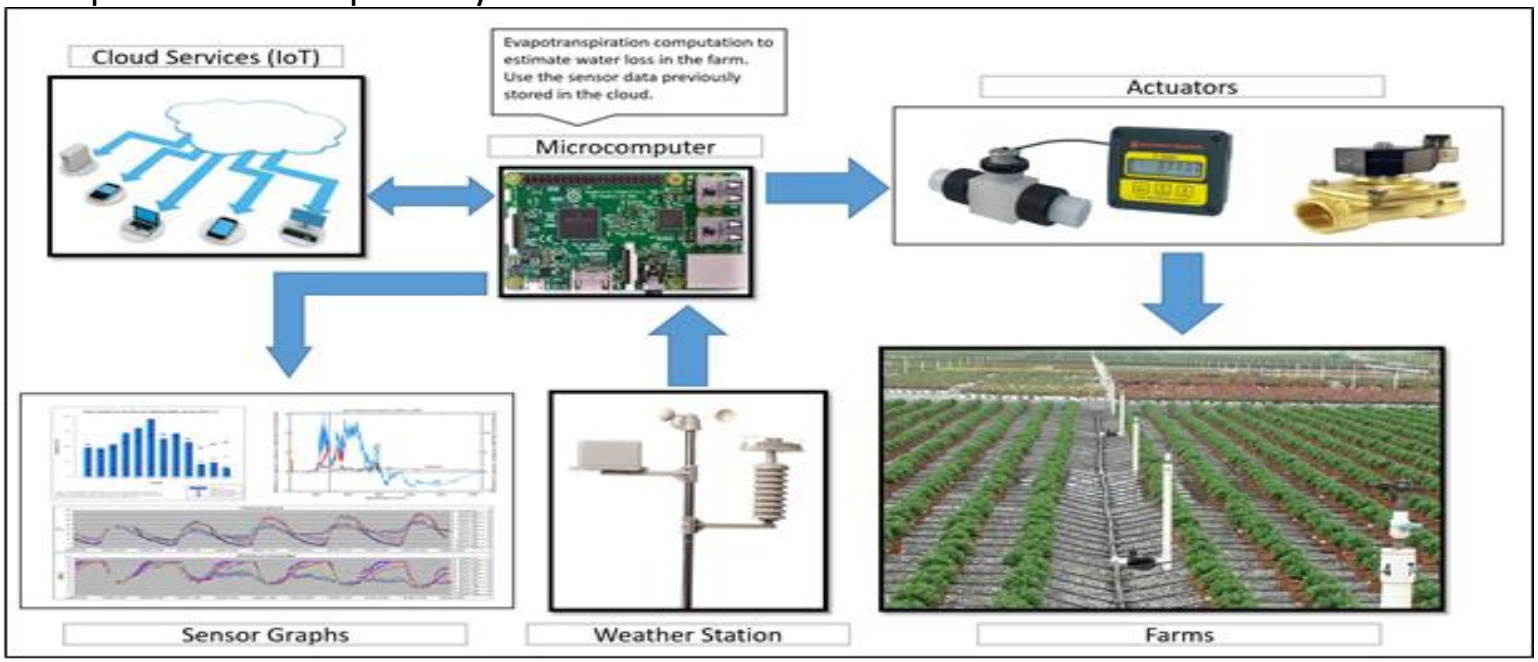
Name	Position/Degree	Department, Institution, Country	Email Address
Meo Vincent C. Caya	Senior Researcher PhD Candidate	MU, Philippines	mvccaya@mapua.edu.ph
Febus Reidj Cruz	Senior Researcher PhD Candidate	MU, Philippines	frgcruz@mapua.edu.ph
Joseph Bryan Ibarra	Senior Researcher	MU, Philippines	jbgibarra@mapua.edu.ph
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 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.
- The main controller of the system is the microcontroller or microcomputer which serves as the heart and brain of the system. It controls the storage of sensor data from the sensor module to the cloud storage. The sensor data will then be used to estimate water loss in the farm by computing ET and controlling the actuators. Irrigation will be based on the computed amount of water loss.
- IoT integration via internet link will be used for transfer of AWS data, irrigation control and crop coefficient repository



Project Activities:

- **Determination of the Crop Coefficient (Cucumber and Corn)**



Cucumber Crop Coefficient Determination



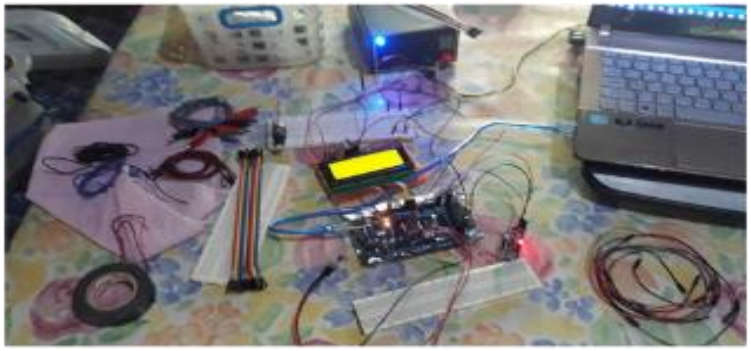


Corn Crop Coefficient Determination

Project Activities:

ET-Based Irrigation System Activities

- **Development of the ET-Based Irrigation System**

Project Activities:

- **Site Visits**



CLSU, Nueva Ecija, Philippines Visit



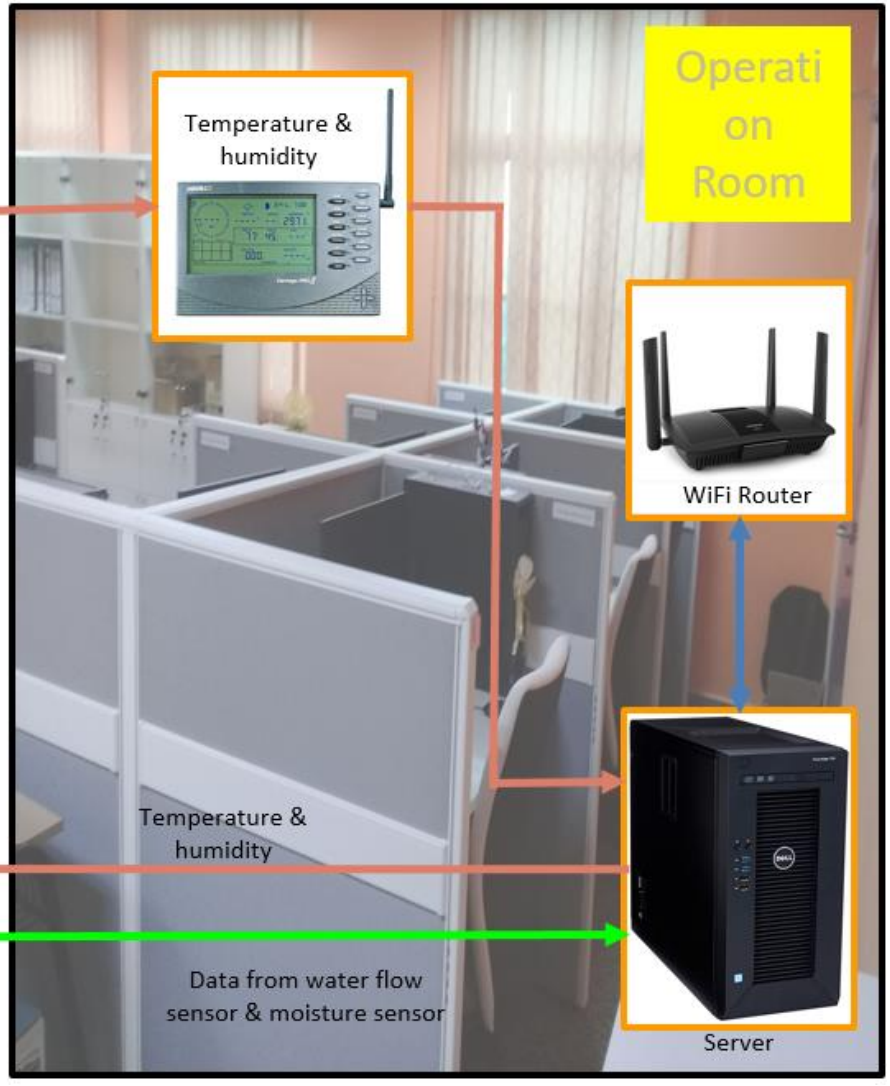
NECTEC, Bangkok, Thailand Visit

Project Activities: CLSU (Evapotranspiration for Corn)

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

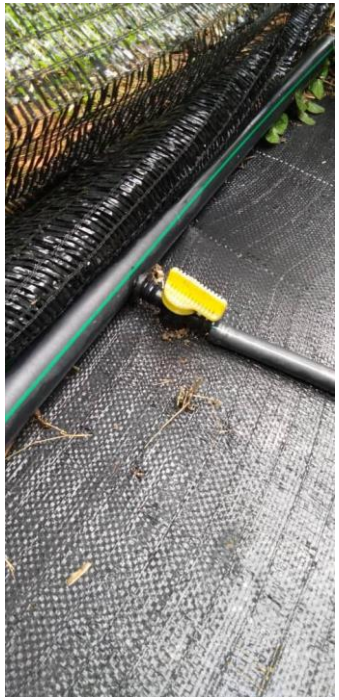
Collected 6-hourly weather data from CLSU PAGASA Synoptic/Agrometeorological Weather Station for the month of November to December 2019 to be used to evaluate the accuracy of the installed weather sensors.

Project Activities: UTM (Evapotranspiration of Chili)



Project Activities: UTM (Evapotranspiration of Chili)

- **Equipment Installation and set up for drip irrigation and site assesment in UTM**



Current Progress:

Plot and irrigation system ready
Hardware procurement completed
Crop coefficient, Kc values for chili are 0.58 (initial stage), 0.95 (mid stage) and 0.73 (end stage)

***Adopted from Muniandy, M. J., Yusop, Z. and Askari, M., Evaluation of reference evapotranspiration models and determination of crop coefficient for Momordica charantia and Capsicum annuum, Agricultural Water Management, vol. 169, pp.77-89, 2016.**

Project Budget: 2017-2020

Budget Spent: 2017-2018

1. Equipment Purchase (MU, CLSU and UTM)
2. Meetings (Year 1 and Year 2)
3. Attendance in Annual ASEAN IVO Forum

Plans for the last phase of the project: 2019

1. Purchase of IoT equipment and devices
2. Site Visit of CLSU and MU members to UTM – January 2020
3. Site visit to MU and CLSU on February-March 2020
4. Conference presentations and publications after the completion of experiments July-December 2020

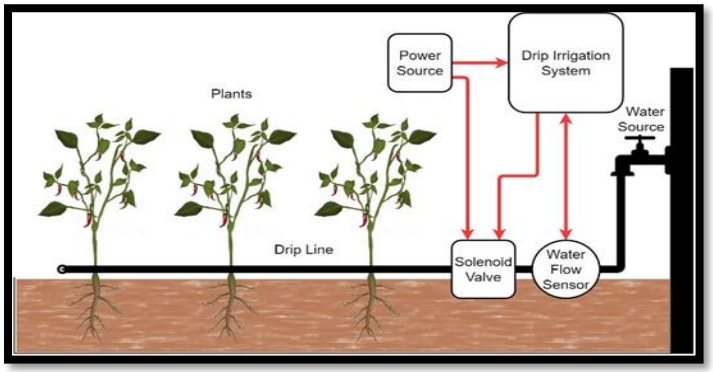
R&D results and Scientific Contribution: Mapua University

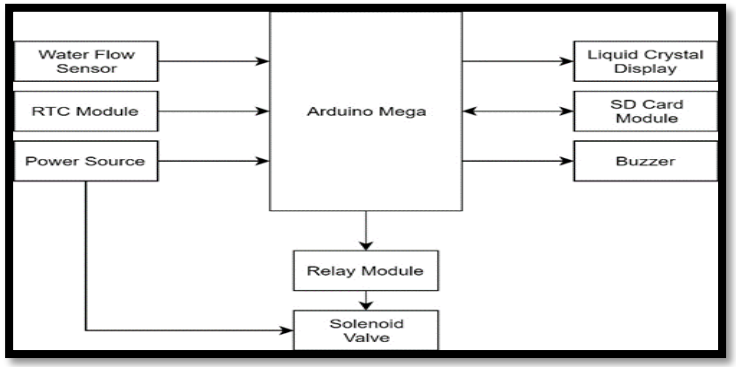
Integration of Water Control with a Drip Irrigation System for Agricultural Application

Abstract: Most drip irrigation systems are controlled and set with an estimated watering duration. However, this requires that the water source has a constant water flow to ensure correct water distribution. Farms that need a drip irrigation system but does not have a capability to provide and maintain constant water flow requires precise and active water control. The research covers the creation of a **drip irrigation system that can adapt to variable water flow input.** It includes the hardware and software development of the system, calibration of sensor, testing, and comparison of the water usage based on system log and the actual water dispensed. For this system, a turbine flow meter with Hall-Effect sensor was used. The research does not comprise of the observation of farms or crops where the system will be applied. With the experiment, the results have shown that trial samples from the System Log and Actual water used are the same and does not have a significant difference. Thus, it is concluded that the system provides the precise amount of water output based on the threshold.

Conference: International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), November 28 – December 1, 2019

Authors: Meo Vincent C. Caya; Adrian G. Narciso; Mariah Camille A. Roque





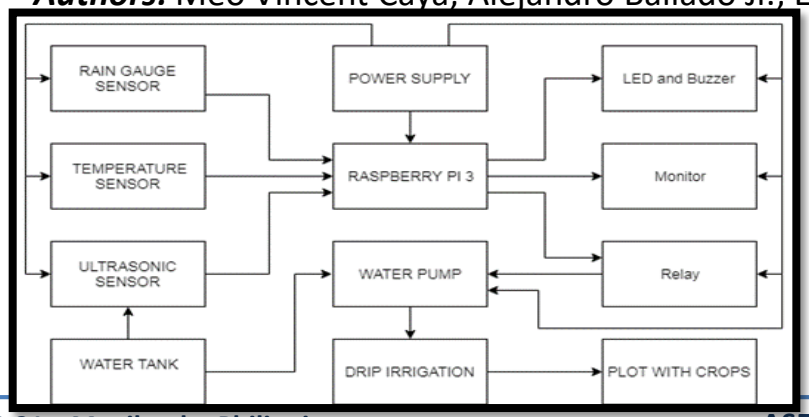
R&D results and Scientific Contribution: Mapua University

ET-Based Smart Irrigation System with irrigation postponement Algorithm for Lycopersicon Esculentum or Tomato plant

Abstract: Agriculture alone consumes an estimate of seventy percent of the amount of freshwater worldwide. In the year 2009, the total water withdrawal for agriculture alone in the Philippines was estimated to be 88 percent recorded by Food and Agriculture Organization (FAO) . However, as an agricultural country, the country has poor irrigation systems. **Poor irrigation systems negatively affect farmers as the misuse of resources can quickly deplete the reservoirs which can be burdensome when El Niño comes.** To aid the major problem mentioned, the researchers proposes a solution through this study. **This study was conducted to produce an automated irrigation system which uses the concept of evapotranspiration to aid in irrigation postponement for Lycopersicon Esculentum, also known as Tomato and describe how implementation of evapotranspiration on smart farming can impact plant growth and water consumption since there is little to no application of evapotranspiration is used in the country.** The researchers used raspberry pi loaded with basic postponement algorithm developed under python programming language and evapotranspiration through Hargreaves-Samani equation. Two planters with two seeds of tomatoes were planted in where one of the planters is grown through traditional method of farming and one grown with the aid of the proposed system. Two-tailed T-Test was used to interpret the data attained. Based from the statistical treatment used, it is proven that that there is no significant effect on the plant growth when proposed system is implemented and there is a 76.86 percent water consumption reduction.

Conference: International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), November 28 – December 1, 2019

Authors: Meo Vincent Caya; Alejandro Ballado Jr.; Eliza Marie C. Rabino; Carl Anthony H. Delim



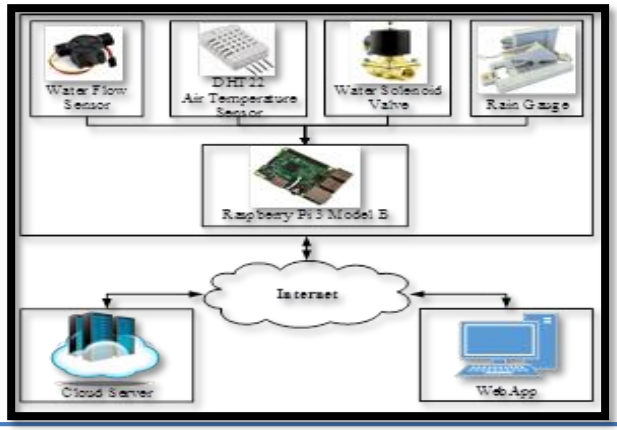
R&D results and Scientific Contribution: Mapua University

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 Journal: For Review and Submission

Authors: Meo Vincent Caya, Ryan Gosiaco, Daniel Jaezon Sablay, Immanuel Robert Sioson, Wen-Yaw Chung



R&D results and Scientific Contribution

Citywide integration for the city of Manila

Societal Impact:

- *In agriculture, to save water is to apply the right amount of irrigation at the right time. Precise irrigation with lesser supervision can be achieved through ET-Based irrigation System with IoT.*
- *The approach requires farm level data such as crop coefficients and weather data that can be made available for farmers and aid them in decision making.*
- *CLSU derived the crop coefficient for corn and other crops. The standard way of determination of Crop coefficient can be used to create a cloud based storage.*
- *In addition, weather data collected from the installed AWS can be provided to farmers covered by its effective radius.*
- *In this way farmers will apply precise amount of irrigation at the time needed which will ensure good crop growth and development, thus optimizes crop yield.*

Conclusion:

Based on the initial experimentations done, implementation of an 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 procedure in determining the crop coefficient have been adopted. The crop coefficient is one of the vital component in the computation of the Actual Evapotranspiration.

Future works:

1. **Integration of different algorithms for the computation of Evapotranspiration**
2. **Determination of Crop Coefficient of different crops in the Philippines and create a database that can be used in the future for the wide implementation of the Proposed Irrigation system**
3. **Development and integration on a mobile application and development of mobile application for the control and monitoring of the proposed ET-Based Irrigation System. The mobile application (Android, IOS) will serve as the main controller of the system. Also, it provides ways on monitoring the environmental parameters from AWS (local or cloudbase environmental data)**
4. **Propose for a Large Scale Integration of the ET-based Irrigation System through funding from a Local Funding Agency (DOST-PCIEERD)**
5. **Report Writing and Publication**