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

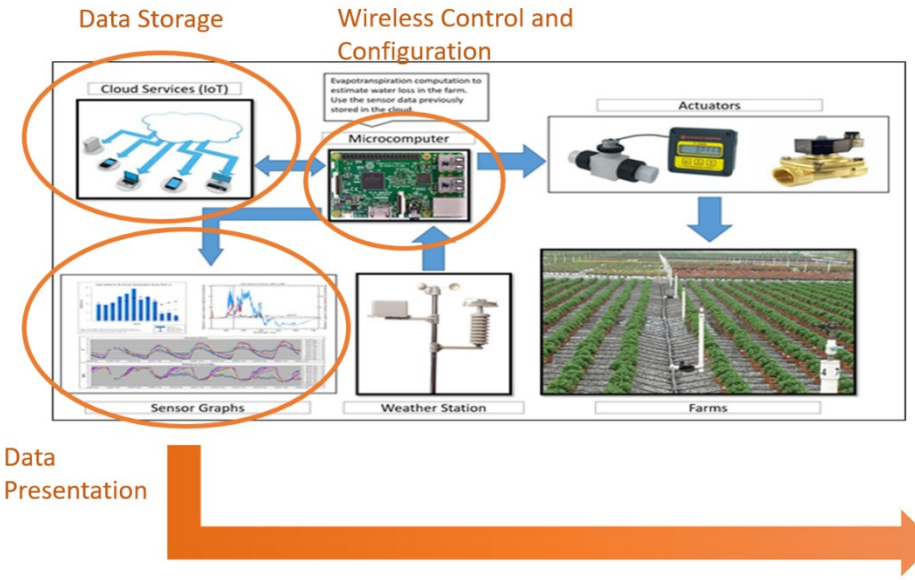
Project Duration : 3 Years

Project Budget: 40,000 USD / Year

Project Activities:

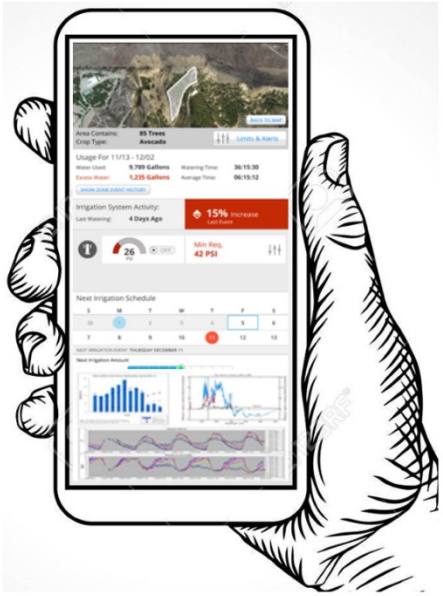
Project Objectives:

- 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



Developed Lab Scale Projects and submitted results to IEEE HNICEM 2020 (under review)

1. Evapotranspiration-Based for Crop Cultivation with Deficit Irrigation Scheme (contributed around 50% of the actual project)
2. Development of Evapotranspiration-based Irrigation System using Hargreaves-Samani Equation for Public Park Application - (contributed around 70% of the actual project)

Conference Presentations and Publications:

3 papers in 2019 IEEE International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)

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**

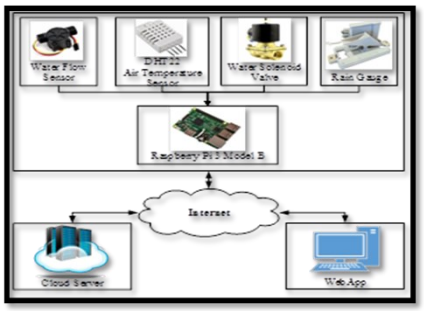
Development of Evapotranspiration-based Irrigation System using Hargreaves-Samani Equation for Public Park Application

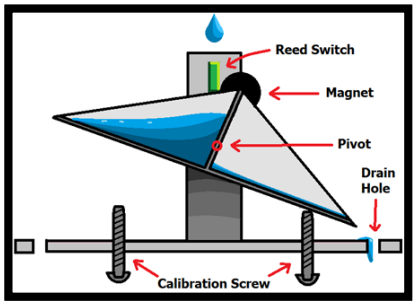
Abstract: Different methods in water saving are applied to maintain the landscapes and reduce the amount of water needed to be irrigated in public parks. Scheduled watering is the most common type of method used by public parks, in which estimating the amount of water leads to over or under irrigation. 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)





Scientific Contribution:

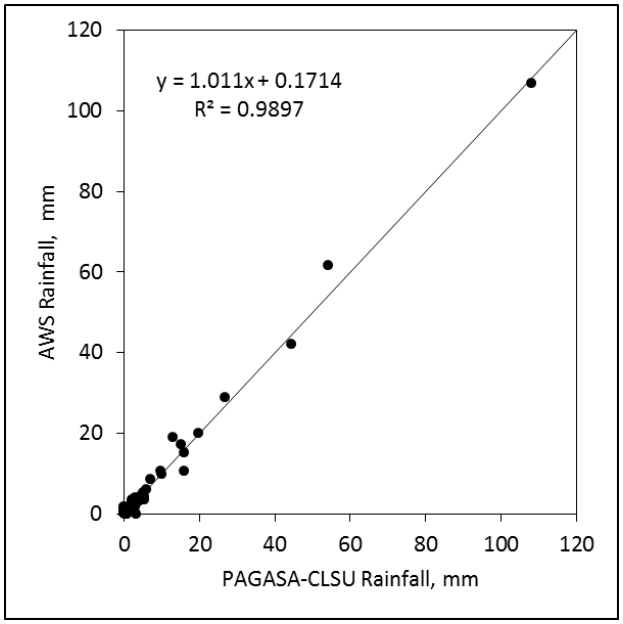
Presentations at International Conferences:

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 Chung-Yuan Christian University, Taiwan	2019 IEEE HNICEM	11/28/2019 – 12/01/2019	Fort Ilocandia, city, Laoag City, 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	11/28/2019 – 12/01/2019	Fort Ilocandia, city, Laoag City, 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	11/28/2019 – 12/01/2019	Fort Ilocandia, city, Laoag City, Ilocos Norte, Philippines

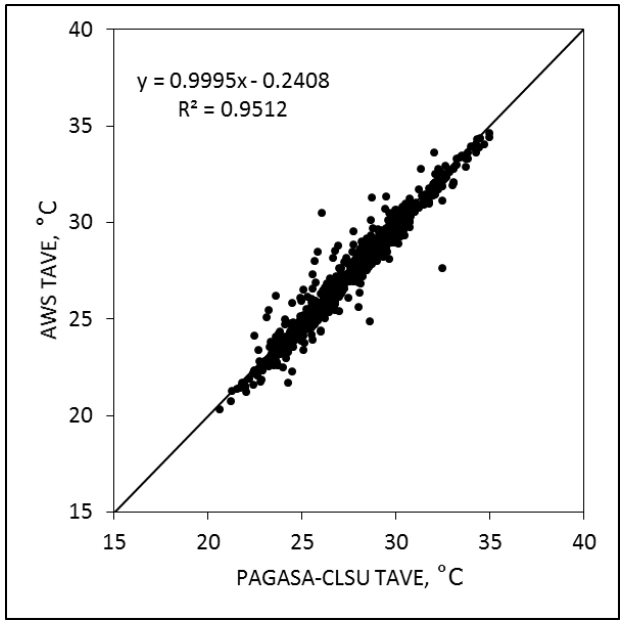
Project Activities: **Central Luzon State University**

- **Calibration and Evaluation of AWS Sensors vs PAGASA Synoptic Weather Station**

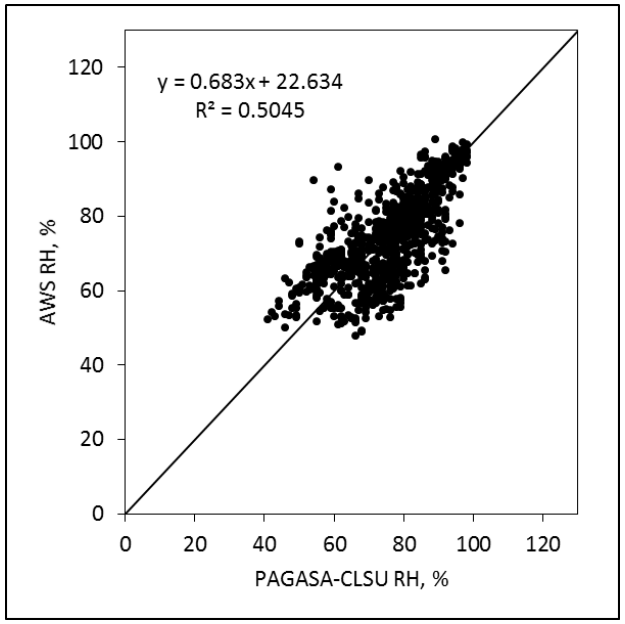
Rainfall and air temperature reading of the AWS were comparable to PAGASA-CLSU Synoptic Weather Station.
Relative humidity of the AWS is moderately comparable to the relative humidity of PAGASA-CLSU Station, this is because PAGASA-CLSU approximated the relative humidity into whole number.



ECRN-100 Rain Gauge



Atmos 14 – Air Temperature



Atmos 14 – Relative Humidity

Project Activities: (Max. 5 slides)

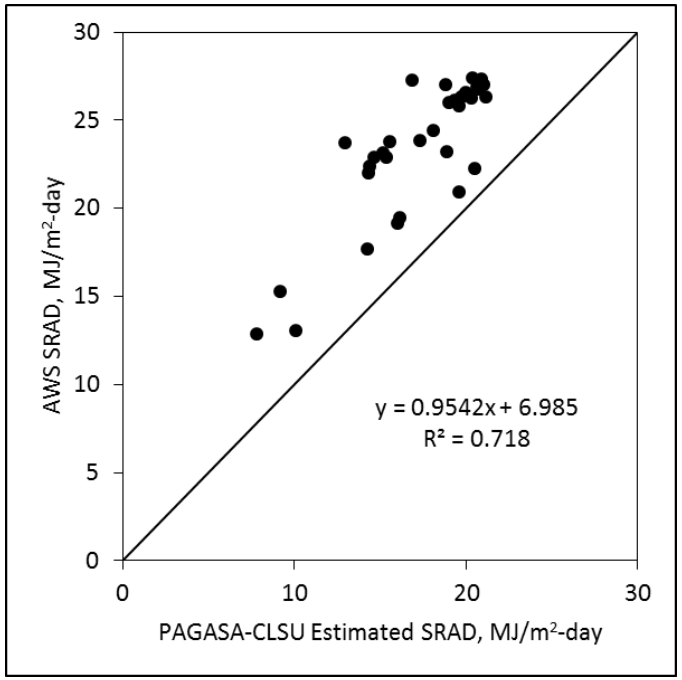
- **Calibration and Evaluation of AWS Sensors**

Wind speed and atmospheric pressure data of the AWS were not compared to PAGASA-CLSU Station because of the large difference in the number of significant figures, the data of PAGASA-CLSU approximated the values into whole number while the AWS data has values up to 9 decimal places.

Measured solar radiation by the AWS overestimates the estimated solar radiation from PAGASA-CLSU station.

Although values of R^2 and the slope indicates good agreement between the measurements.

The 3 months data gathered from the acquired AWS is in good agreement with PAGASA readings. The AWS is now ready for integration to the controller.



PYR Solar Radiation

Project Activities: Site Visit and Meeting, 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: Site Visit and Meeting, MU and CLSU (Nov 13-14, 2020)

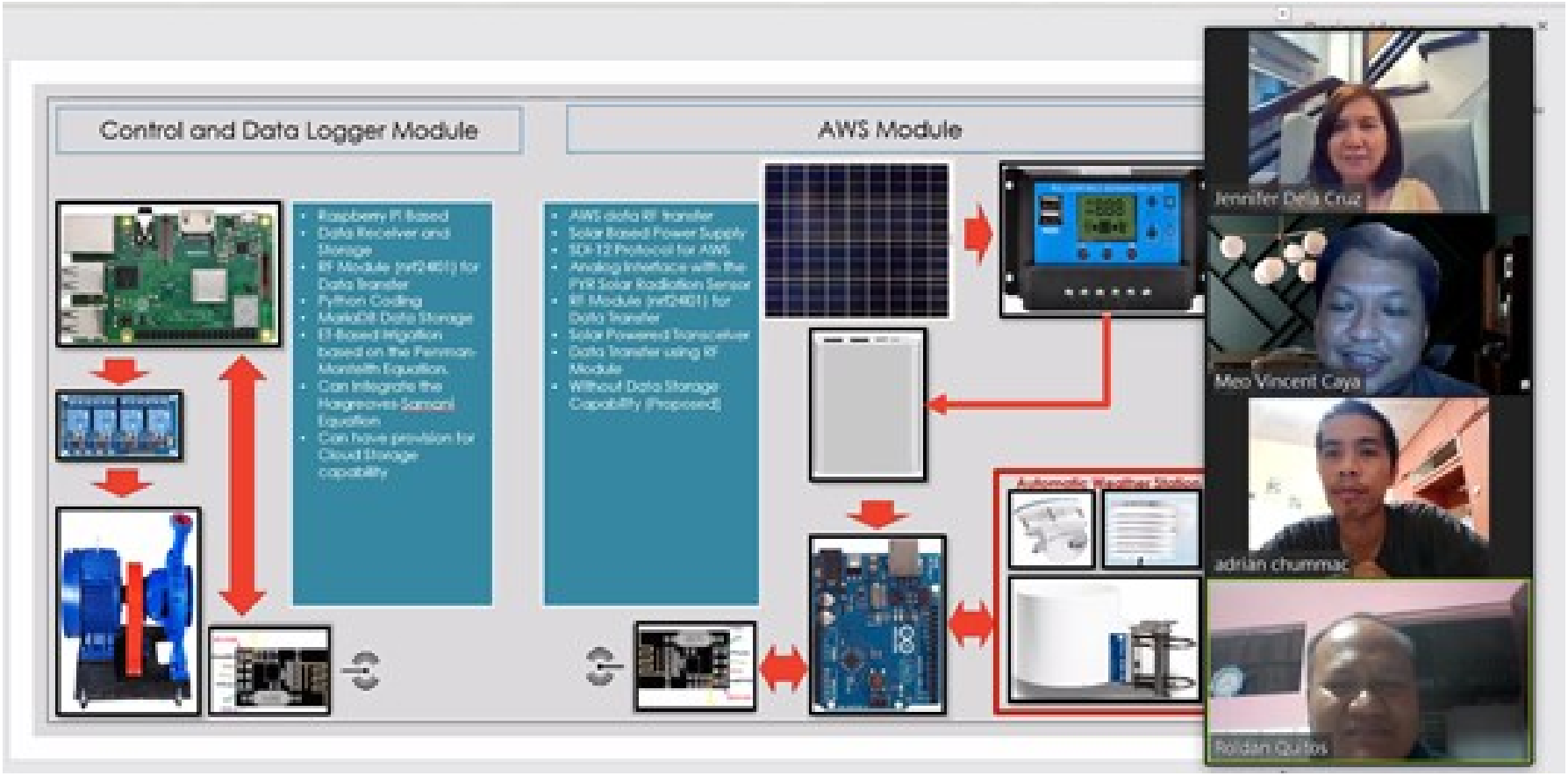
*AWS sensors were removed before the landing of the 3 consecutive super typhoons

Original site that is always submerged in water

New site after clearing
Ready to plant once the automatic irrigation system is fully setup.

Project Activities: Virtual Meeting MU and CLSU – Nov 20,2020

Follow up meeting for the discussion and demonstration of customized data logger and control system.



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

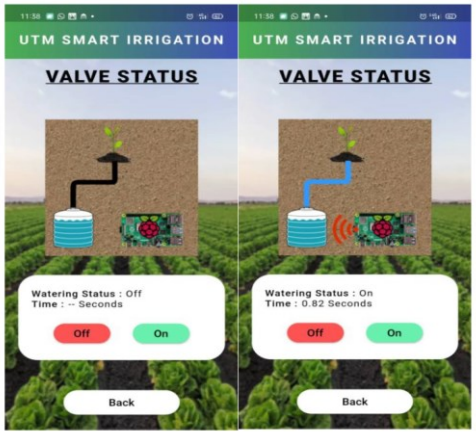
Evapotranspiration (ET)-Based Irrigation System with Internet of Things (IoT) Integration for *Capsicum Annuum*

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



Project Budget: 2017-2020

Budget Spent: 2019-2020 approx $10,400

1. Equipment Purchase (MU, CLSU and UTM)
2. Site Visit – November 13-14,2020
3. Conference Presentation – Nov 9, 2020

Plans for the last phase of the project: 2021 approx $ 6,000

1. Site visit to CLSU on January 2021
2. Final Meeting of members (Virtual) – March 2021
3. Conference presentations and publications after the completion of experiments July-December 2021

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**