ASEAN -IVO PROJECT 2017

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

PROGRESS REPORT 2018

MAPÚA UNIVERSITY

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UTM UNIVERSITI TEKNOLOGI MALAYSIA

Outline

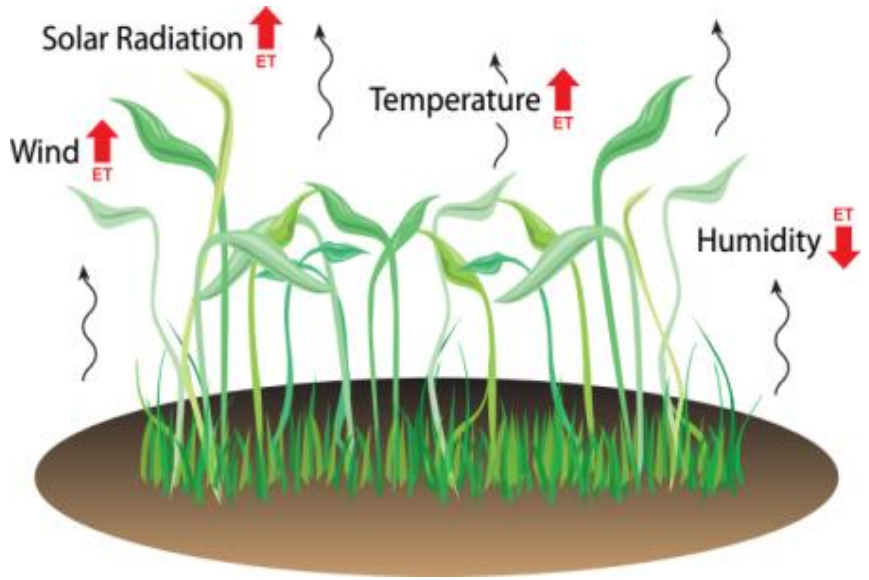
- **Evapotranspiration and Crop Coefficient for Corn in Nueva Ecija**
  - Background of the study
  - Determining Crop Coefficient (Kc) of Corn
- **Project Meeting and Visit to CLSU**
- **Evapotranspiration and Crop Coefficient for Cucumber on a Hilly Land Location as Parameter for an Automated Irrigation System**
  - Background of the study
  - Determining Crop Coefficient (Kc) of Cucumber using clay pot setup
  - Development of Automated Irrigation System
- **Equipment Acquisition Status**

Evapotranspiration

•Evapotranspiration (ET) is the sum of evaporation from the land surface plus transpiration from plants.

• ET determines when and how much irrigation water is needed.

•Evapotranspiration (ET) is an energy-driven process. ET increases with temperature, solar radiation, and wind. ET decreases with increasing humidity.



Determining Crop Coefficient (Kc)

- Crop Coefficient

$$Kc = \frac{ETc}{ETo}$$

Where:

- ET_C or ET_a is the crop evapotranspiration/actual ET
- K_C is the crop coefficient
- ET_O is the potential/reference evapotranspiration

- Note that each crop has its own k_c, as well as ET_c. Hence, irrigation scheduling differs from one crop to another.

Evapotranspiration and Crop Coefficient for Corn

- Potential or Reference Crop Evapotranspiration, ETp.
- Using Hargreave's ETp equation
- $ETp = 0.0162(T + 17.78)Rs$ (1)
-
- where:
- ETp = daily potential evapotranspiration of corn, mm/day
- T = daily average temperature, ^0C
- Rs = daily solar radiation, langleys/day

Evapotranspiration and Crop Coefficient for Corn

- **Daily Consumptive Use, CU or ETa. Daily CU was determined by conducting a field experiment. That is, corn was planted in the field and the daily soil moisture content was determined. The difference in soil moisture content between two successive days is the CU for the previous day.** (Some values of CU are also given in Table 1. Other values are still being determined)
- **Daily Crop Coefficient, Kc. Daily Kc was computed using Table 1. The generated Kc, from the first day to the last day of the growing period of corn will be used to establish a Kc equation which is yet to be done.** (1 season trial)

Table 1. Daily ETp, CU and Kc for corn from September 10 to October 26, 2018

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Date	ETp (mm/day)	CU (mm/day)	Kc
Sept. 10			
11	8.87	0.07	0.008
12	8.94	0.09	0.010
13	9.04	0.11	0.012
14	8.04	0.13	0.016
17	8.79	0.14	0.016
18	8.99	0.16	0.017
19	9.12	0.19	0.020
20	8.78	0.19	0.022
21	8.86	0.21	0.023
24	9.00	0.32	0.036
25	9.05	0.36	0.040
26	8.97	0.41	0.045
27	9.06	0.47	0.052
28	9.08	0.50	0.055
Oct. 1	8.17	0.53	0.065
2	7.99	0.58	0.072
3	7.84	0.64	0.082
4	7.95	0.69	0.087
5	7.75	0.73	0.095
8	8.18	0.78	0.095
9	8.30	0.80	0.097
10	8.26	0.83	0.100
11	8.06	0.85	0.107
12	8.28	0.89	0.11

Table 1. Daily ETp, CU and Kc for corn from September 10 to October 26, 2018

15	Computation is on-going	0.92	Computation is on-going
16	Computation is on-going	0.97	Computation is on-going
17	Computation is on-going	1.01	Computation is on-going
18	Computation is on-going	1.04	Computation is on-going
19	Computation is on-going	1.08	Computation is on-going
22	Computation is on-going	1.10	Computation is on-going
23	Computation is on-going	1.15	Computation is on-going
24	Computation is on-going	1.18	Computation is on-going
25	Computation is on-going	1.24	Computation is on-going
26	Computation is on-going	1.26	Computation is on-going
Oct. 29-31 – No data gathered due to Typhoon occurrence			
Nov 1 to present – Data are still being consolidated			

Note the daily T and Rs were collected from a nearby agro-meteorological station because the project does not have an automatic weather station (AWS) yet.

Evapotranspiration and Crop Coefficient for Corn

- Once the Kc equation is established, it will be used to compute the daily actual evapotranspiration, ETa by the equation

$$ETa = KcETp \qquad (2)$$

where Kc and ETp were as defined earlier.

Note that the daily ETa is the amount of water to be applied by triggering the operation of a pump. Triggering the pump is the function and output of our IoT project.

Determination of Daily Soil Moisture Content (for Eta)

Removing of top soil, about 10 cm in depth

Getting Approximately 200g of soil samples (at least 3)

Removing of inert matter present in the sample

Determination of Moisture Content in Soil

Weighing of Soil Sample

Oven Drying of Soil Sample, overnight at 105 °C (12-24hrs)

Weighing of Oven Dried Soil Sample

The change in daily soil moisture content is the actual evapotranspiration of the crop. Hence, there is a need to monitor/determine the daily soil moisture in order to determine the daily evapotranspiration.

1st Corn Production

June 4 – July 1

Land Preparation

Planting

Flood Caused by Typhoon
Domeng June 8-11, 2018

2nd Corn Production

July 13 – September 10

Soil Filling in 20L cans

Planting

Two weeks old Corn plants

Four weeks old Corn plants

8 weeks old Corn Plants

2nd Corn production devastated
by Typhoon Ompong
Devastated the area on
September 12-14, 2018

3rd Corn Production

Sept 4 - Present

Land Preparation

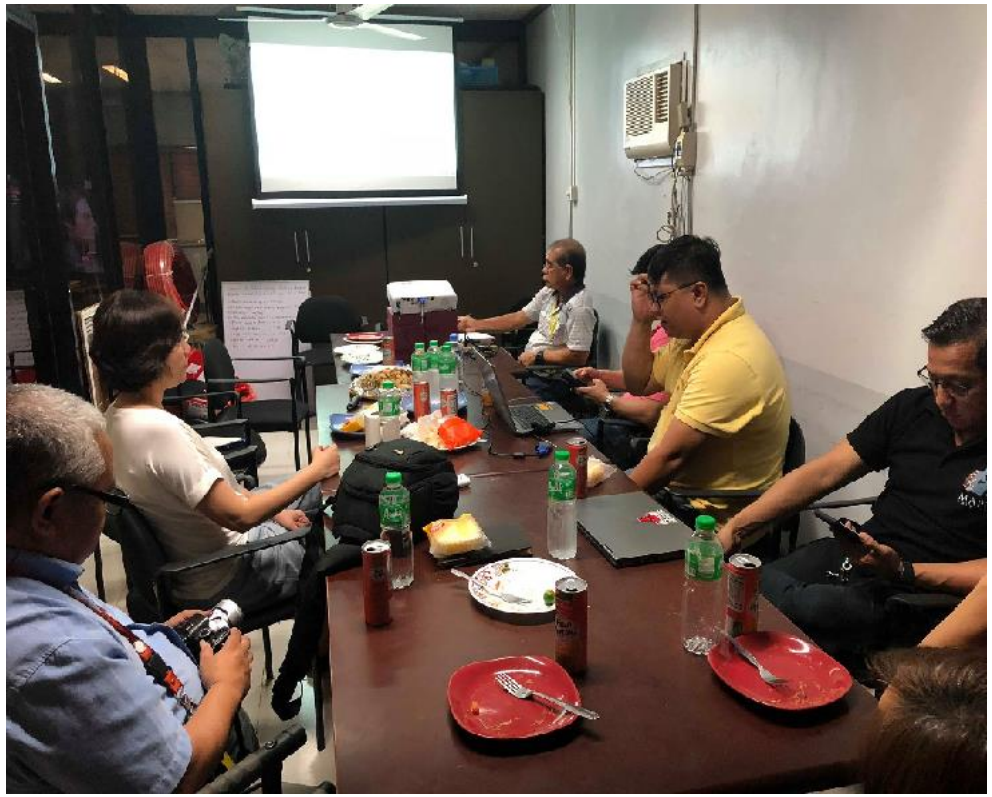
Planting

Corn Vegetative Stage

Reproductive Stage

3rd Corn production devastated by Typhoon Rosita
on October 30-31, 2018

Project visit to CLSU (Meeting and discussion) October 26, 2018



Project visit to CLSU (Meeting and discussion) October 26, 2018

Evapotranspiration and Crop Coefficient for Cucumber on a Hilly Land Location as Parameter for an Automated Irrigation System

- Background of the study
  - Evapotranspiration (ET)
    - Sum of the vaporization of liquid water from surface water (evaporation) and plants (transpiration)
  - Reference Evapotranspiration (ETo) *Note: ETo was computed using Priestley-Taylor equation
    - Evapotranspiration from a hypothetical reference grass crop (alfalfa)
  - Crop Evapotranspiration (ETa/ETc)
    - Evapotranspiration from a specific field crop
  - Crop Coefficient (Kc)
    - Describes the effects of characteristics that distinguish field crops from reference grass crop

Cont.

- There is no existing irrigation system in Brgy. Cuyambay, Tanay, Rizal that uses evapotranspiration and crop coefficient as its parameter.
- The amount of water they irrigate is based on their wisdom and experience. And continuous supply of water is a problem.
- They used solar powered pumps to store water for irrigating the farms.
- Location: Brgy. Cuyambay, Tanay, Rizal

Cont.

- Clay Pot Setup

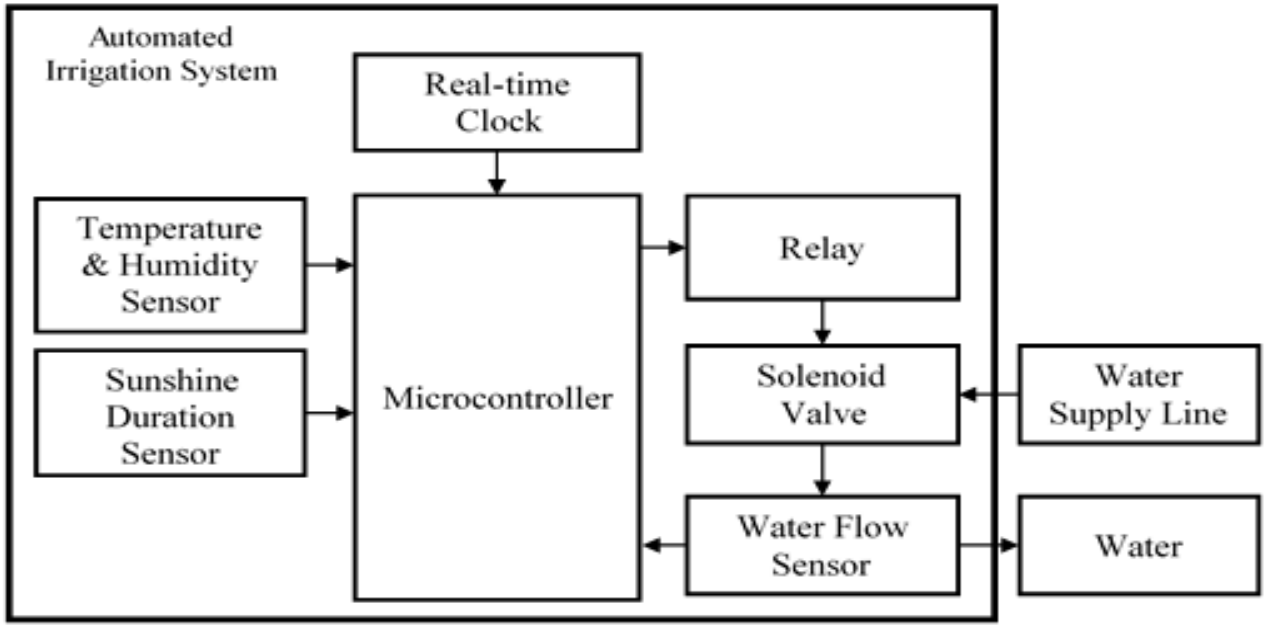
Cont.

Growth Stage	Kc Value
Initial	0.35
Middle	0.75
Late	0.65

Computed Kc Values

Development of Automated Irrigation System

- Hardware Development



Block Diagram of the System

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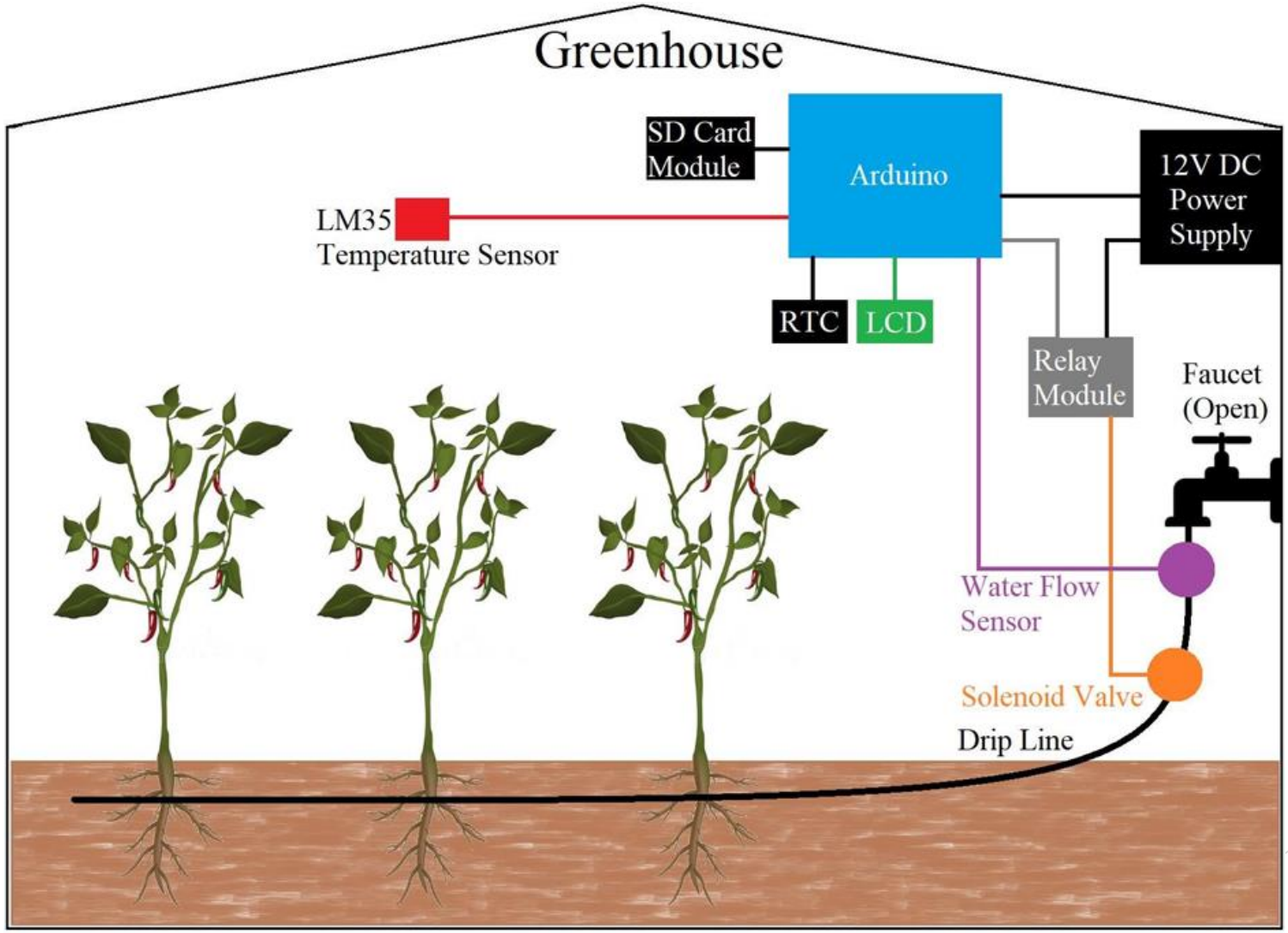
- Prototype Setup

Hardware Design

- System



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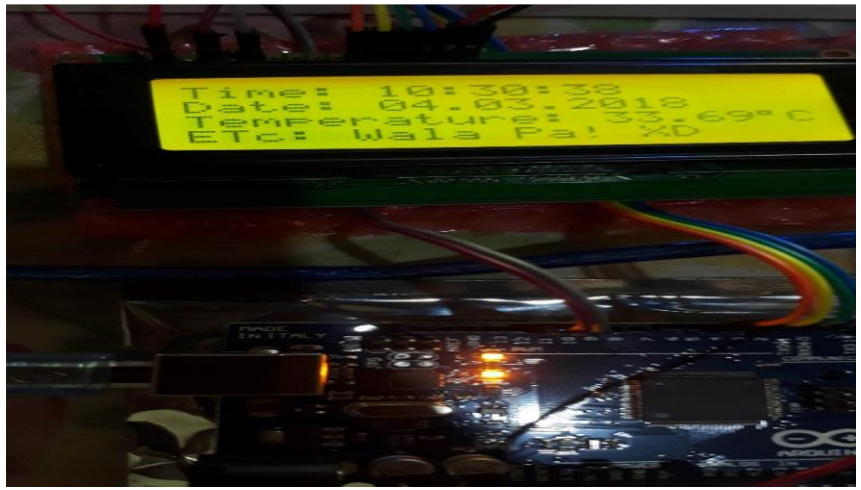

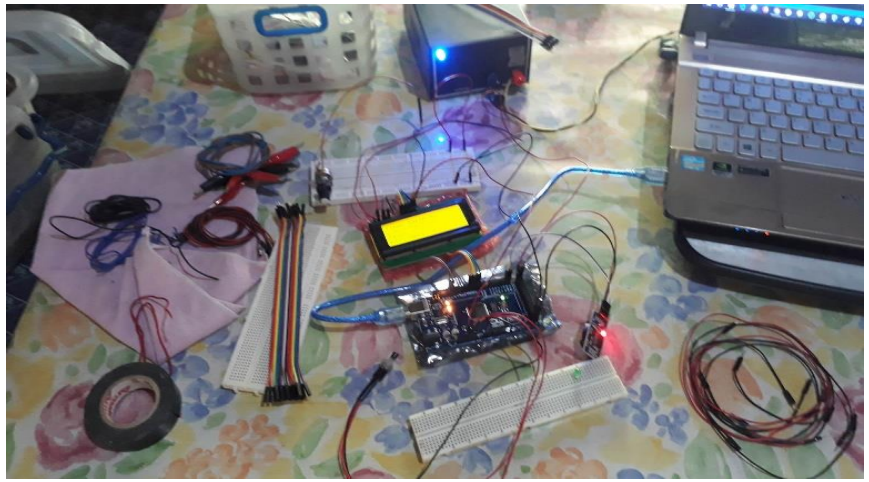

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- Sample Implementation

Equipment Acquisition Status

Purchase request by Mapua University is in process

Name	Description	Quantity	Local Supplier	Price in PhP	Subtotal in PhP (plus VAT)
Arduino Starter Kit	This serves as the main control unit of the sensor and actuator network that will control the irrigation through the drip irrigation system	3	Jassen Harris Industries Corporation	1825.00	5475.00
Raspberry Pi 3 Model B SBC	This serves as the main control unit of the sensor and actuator network that will control the irrigation through the drip irrigation system	3	Jassen Harris Industries Corporation	3600.00	10800.00
METER Automatic Weather Station (Formerly DECAGON DEVICES)	Rain gauge, temperature sensor, solar radiation sensor, leaf wetness sensor, anemometer and data logger.	1	Philippine Instuments Corp	195000	195000.00
Data Server	PowerEdge T30 Server Chassis Configuration : Chassis with up to 4, 3.5 inch Hard Drives Processor : Intel Xeon E3-1225 v5 3.3G, 8M cache, 4C/4T, turbo (80W) Memory Capacity : 8GB UDIMM, 2400MT/s, Single Rank, x8 Data Width RAID Configuration : Onboard SATA, HDD connected to onboard SATA Controller - No RAID Hard Drives : 1TB 7.2K RPM SATA 6Gbps Entry 3.5in Cabled Hard Drive Internal Optical Drive : DVD+/-RW SATA Internal Power Cords : US 125V Power Cord Operating System : No Operating System	1	Anything Gaming	37800	37800.00
router	TP Link Archer C5400 Tri Band MU MIMO	1	Lazada	15598	15598.00
Solenoid Valve	Solenoid Valve - Brass 12VDC G1	2	Jassen Harris Industries Corporation	3000	6000.00
Drip Irrigation	Drip System - 25m DIY Micro Drip Irrigation System Self Watering Garden Hose Kits	4	Jassen Harris Industries Corporation	1600	6400.00
Flow Meter	Water Flow Sensor G1	2	Jassen Harris Industries Corporation	1000	2000.00
Laptop	Dell Inspiron15 7588 CORE I7 (BLACK/ WHITE) 8th Generation Intel Core i7-8750H Processor (6-Core, 9MB Cache, up to 4.1GHz w/ Turbo Boost) 1TB 5400 rpm Hard Drive +128GB Solid State Drive 8GB, 1x8GB, DDR4, 2666MHz NVIDIA GeForce GTX 1050 Ti with 4GB GDDR5 graphics memory	1	Integrated Computer Systems, Inc.	73700	73700.00
Soil Moisture	Moisture Sensor - Soil Moisture Sensor Corrosion Resistant DFRobot	6	Jassen Harris Industries Corporation	500	3000.00
	TOTAL				355773.00

Equipment Acquisition Status

Purchase request by CLSU is in process c/o MU

Name	Description	Quantity	Local Supplier	Price in PhP	Subtotal in PhP (plus VAT)
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Laptop	ACER Aspire E5- 576G	1	Integrated Computer Systems, Inc.	49700	49700.00
router	TP Link Archer C5400 Tri Band MU MIMO	1	Lazada	15598	15598.00
Solenoid Valve	Solenoid Valve - Brass 12VDC G1	2	Jassen Harris Industries Corporation	3000	6000.00
Drip Irrigation	Drip System - 25m DIY Micro Drip Irrigation System Self Watering Garden Hose Kits	4	Jassen Harris Industries Corporation	1600	6400.00
Soil Auger	Oakfield Model C 36" Soil Auger	1	Philippine Instuments Corp	42500	42500.00
Water Pump Set	Water pump set- offer : 2HP single phase, PEDROLLO BRAND,132 gallons (528 liters) GPM, 72ft. TDH	1	Conmaster Merchandising Corp	27150	27150.00
Soil Auger	Oakfield Model A 36" Auger Tube kit	1	Philippine Instuments Corp	47500	47500.00
Flow Meter	Water Flow Sensor G1	2	Jassen Harris Industries Corporation	1000	2000.00
Soil Moisture	Moisture Sensor - Soil Moisture Sensor Corrosion Resistant DFRobot	6	Jassen Harris Industries Corporation	500	3000.00
Shipping Fee	Delivery Charges to CLSU	1	Jassen Harris Industries Corporation	500	500.00
	TOTAL				411623.00

Plans upon arrival of equipment

- Conduct additional trials on ET and Kc for corn using our own AWS
- Design and development of sensor boards and microcontrollers
- Calibration of sensors and devices
- Design and development of automatic irrigation
- System set up including IoT
- Application and data server management

References

- www.pagasa.dost.gov.ph

- Reference Module in Earth Systems and Environmental SciencesEncyclopedia of Soils in the Environment/www.sciencedirect.com/science/article/pii/B0123485304003593

- Fruits & Vegetables Seed Center, Munoz, Nueva Ecija

- Treatise on Geochemistry Volume 5, 2003, Pages 169-188

Thank You