

Internet of Things (IoT)-based Precision Irrigation with LoRaWAN Technology Applied to High Tunnel Vegetable Production

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Introduction

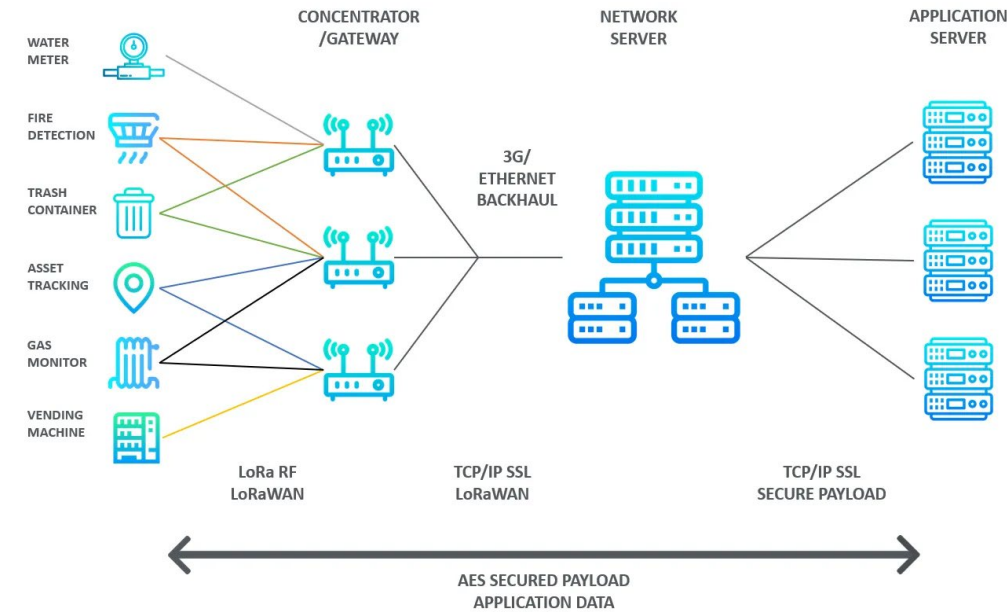
- Agriculture consumes approximately 80% of water use in the United States
- As the global population increases, crop production is expected to increase while water resources are increasingly limited

Introduction

- Conventionally, irrigation based on experiences causes inefficient water usage and crop yield and quality reduction.
- Precision irrigation: Applying only the necessary amount of water directly to the crop
- Lower cost of irrigation water and manpower, and improvement of crop yield and quality
- Based on Evapotranspiration (ET)/crop water stress/soil moisture
- Soil water content: water volume/soil volume
- Soil water potential: capability soil holds water

Introduction

- IoT system
- Uploading sensor data to the Internet.
- Analyzing sensor data and controlling irrigation on the Internet
- Various network types used in IoT-based irrigation: Wi-Fi, Bluetooth, ZigBee, Sigfox, cellular network (GPRS, EDGE, LTE), LoRaWAN



Source: <https://tekzitel.com/what-is-lorawan/>

Technology	Network type	Frequency	Range	Data rate	Power	Security
LoRaWAN	LPWAN	915 MHz	10 km	0.3-50 kbps	10mW	AES 128 bit
LTE	GERAN/UTRAN	700-2600 MHz	10 km	0.1-1 Gbps	1 W	3GPP 128-256 bit
Wi-Fi	WLAN	2.4, 3.6, 5 GHz	100 m	6-780 Mbps	1 W	WEP, WPA, WPA2

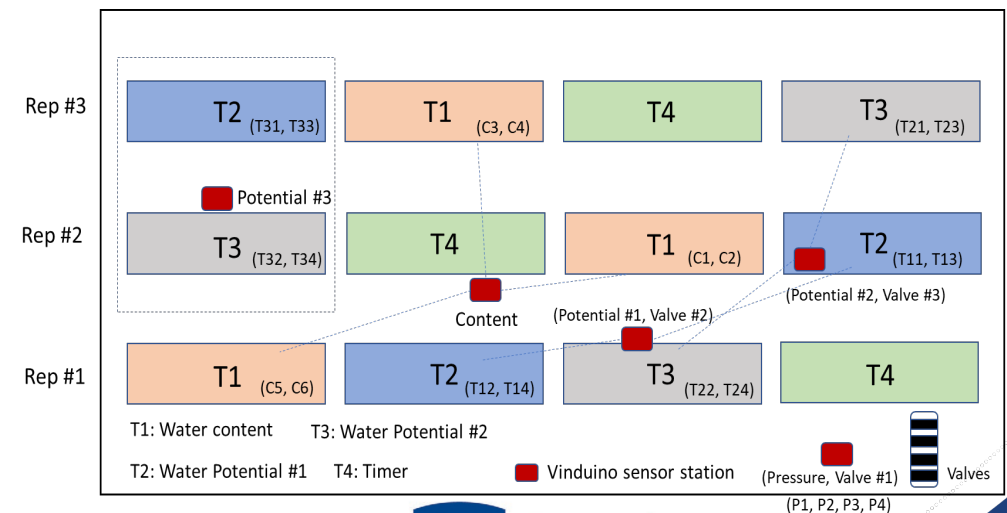


Objectives

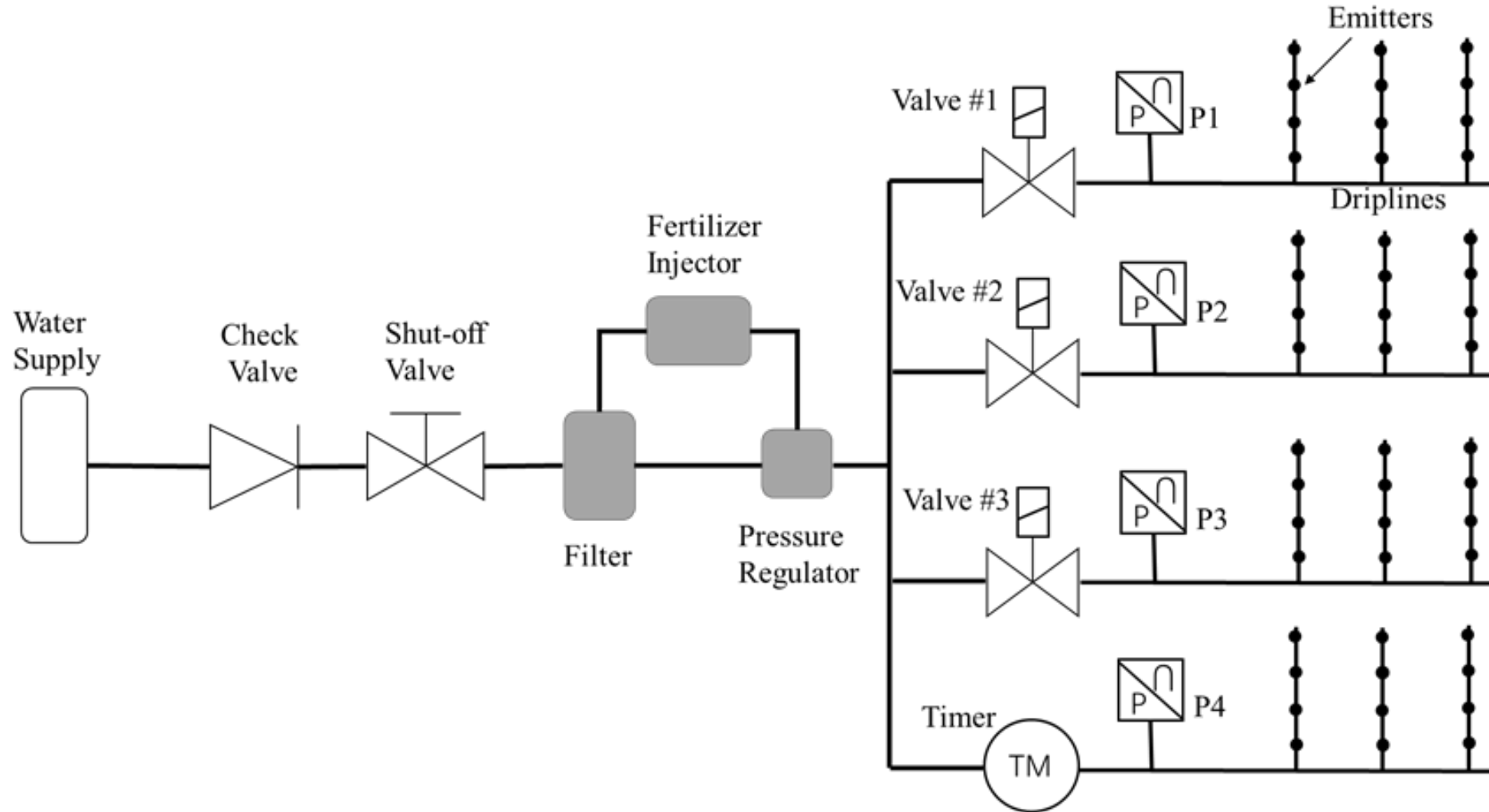
- Investigating the applicability of soil water content and soil water potential sensors in the developed irrigation system
- Conducting functionality evaluation on the irrigation system in terms of data communication and irrigation execution

Method: Experimental Setup

- Red cabbage (*Brassica oleracea* cultivar Omero F1)
- T1: Soil water content
- T2: Soil water potential #1 (-30 kPa)
- T3: Soil water potential #2 (-60 kPa)
- T4: Timer
- 3 replicates
- 2 depths (15 cm, 30 cm)



Method: Irrigation system



Method: Sensor system

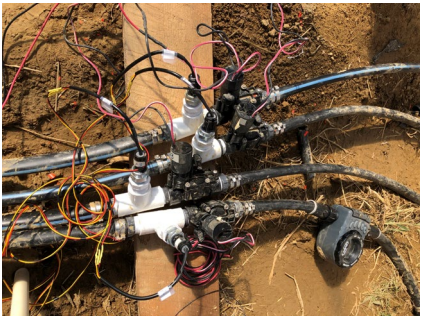
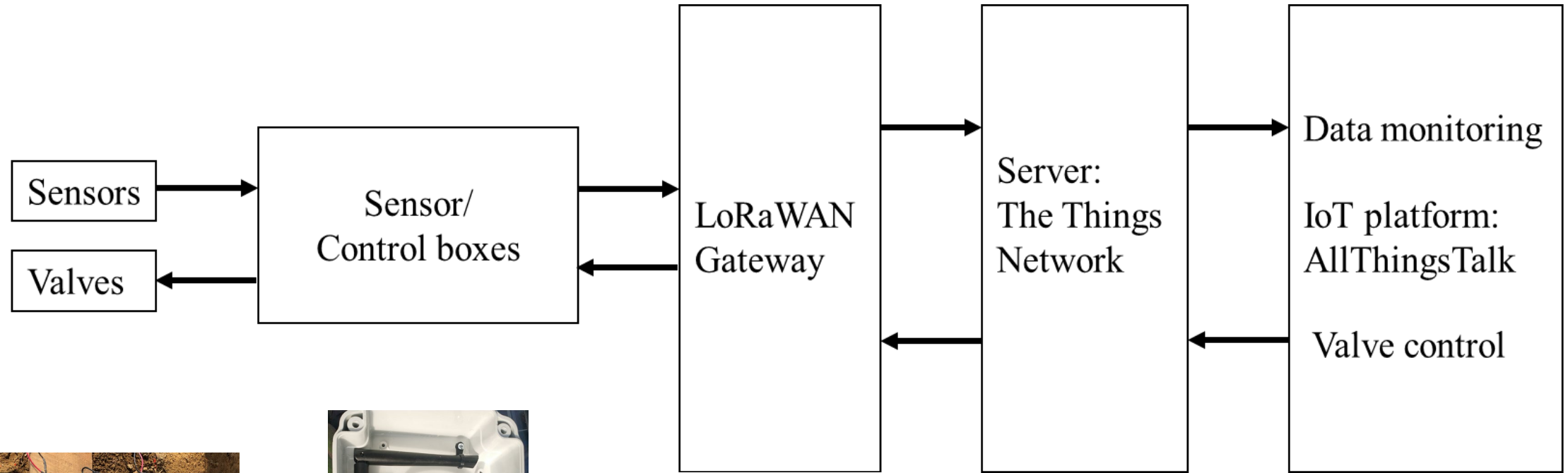
- 6 soil water content sensors
- TEROS 10, METEER Group, Inc., Pullman, WA



- 12 soil water potential sensors
- Watermark 200SS-5, Irrrometer company, Inc., Riverside, CA



Method: IoT system



Method: IoT system

The screenshot displays the AllThingsTalkMaker IoT dashboard. The interface includes a top navigation bar with a home icon, the text "Playground", and an "AllThingsTalkMaker" title. On the right of the top bar are buttons for "UPGRADE", a help icon, a chat icon, and a user profile icon. A left sidebar contains navigation options: DEVICES, PULSE, PINBOARDS (highlighted in red), GATEWAYS, MEMBERS, RULES, and SETTINGS. The main content area is titled "vegetable-irrigation" and features a "+ NEW PINBOARD" button and "SHARE", "EDIT", and "DELETE" icons. The dashboard is organized into a grid of data cards, each representing a different sensor or device. Each card shows a numerical value, a status indicator (like a toggle switch or a camera icon), and a refresh interval (e.g., "3 d", "7 d", "1 d").

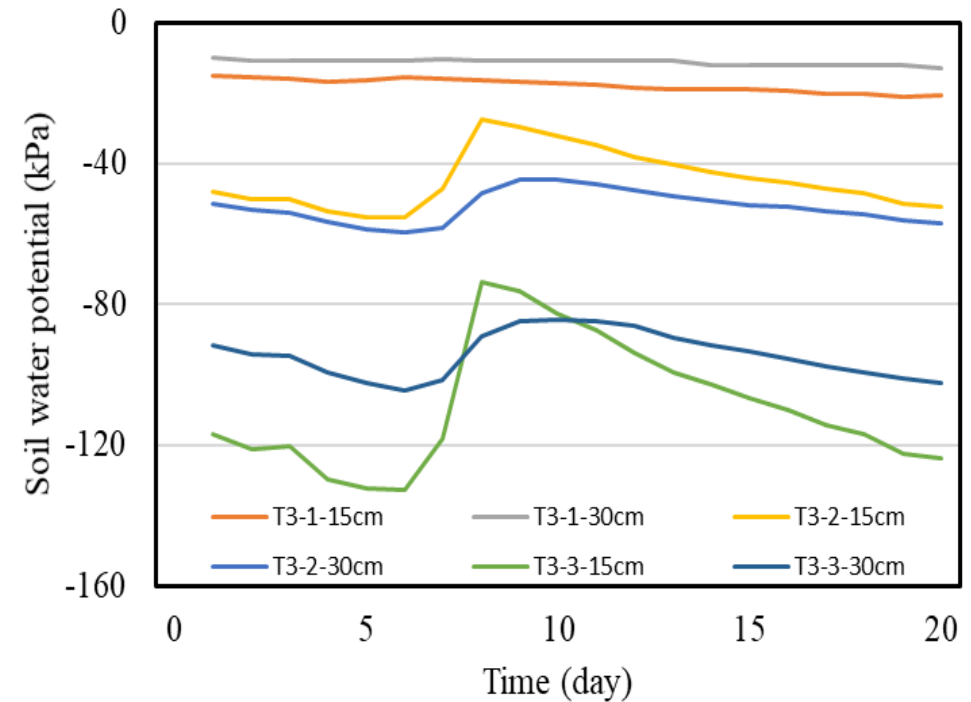
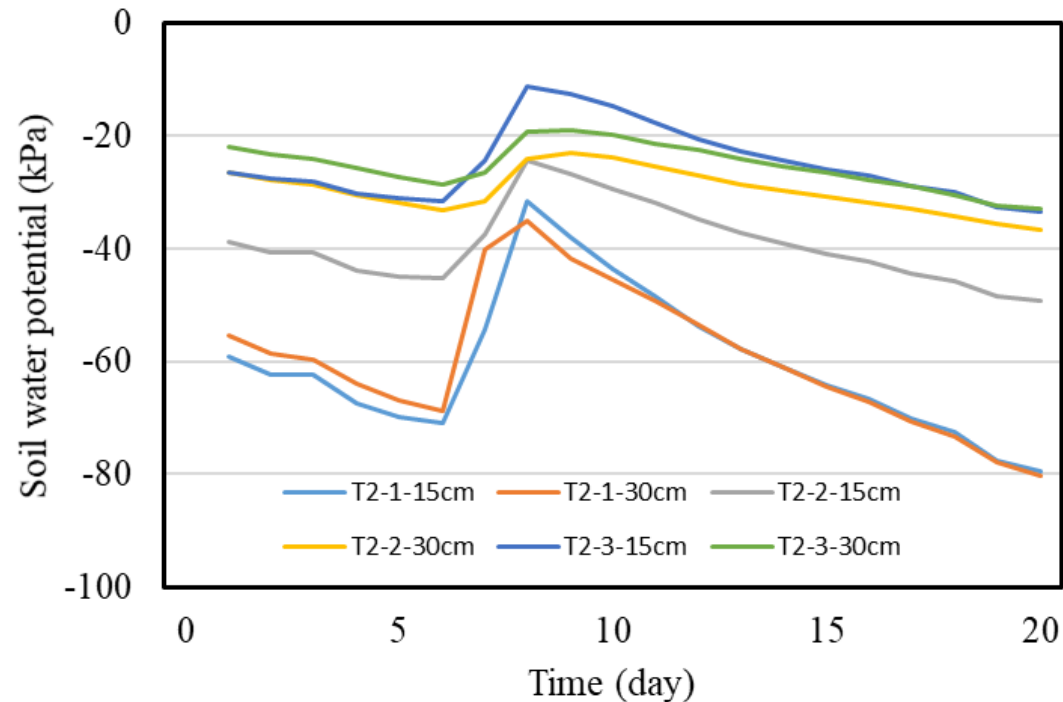
Device Name	Value	Refresh Interval	Status/Indicator
BatVp	3.7	3 d	
p1	5.59	3 d	
p2	5.59	3 d	
p3	5.59	3 d	
p4	6.39	3 d	
v1			Toggle Switch (Off)
v1status		3 d	Camera Icon
BatVc	3.72	7 d	
c1	0.31	7 d	
c2	0.28	7 d	
c3	0.35	7 d	
BatVc	3.7	6 d	
c4	0.34	6 d	
c5	0.35	6 d	
c6	0.33	6 d	
BatVt1	3.7	1 d	
t11	75	1 d	
t12	47	1 d	
t13	78	1 d	
t14	36	1 d	
v2			Toggle Switch (Off)
v2status		1 d	Camera Icon
BatVt2	3.7	1 d	
t21	18	1 d	
t22	50	1 d	
t23	12	1 d	
t24	56	1 d	
v3			Toggle Switch (Off)
v3status		1 d	Camera Icon

Results: Feasibility of the IoT system

- 300 m between high tunnel and gateway
- 4.3 % signal loss
- Control the valve on the IoT platform
- Batteries work for 2 months with a solar panel
- More battery consumption for soil water content sensors because of continuous power supply

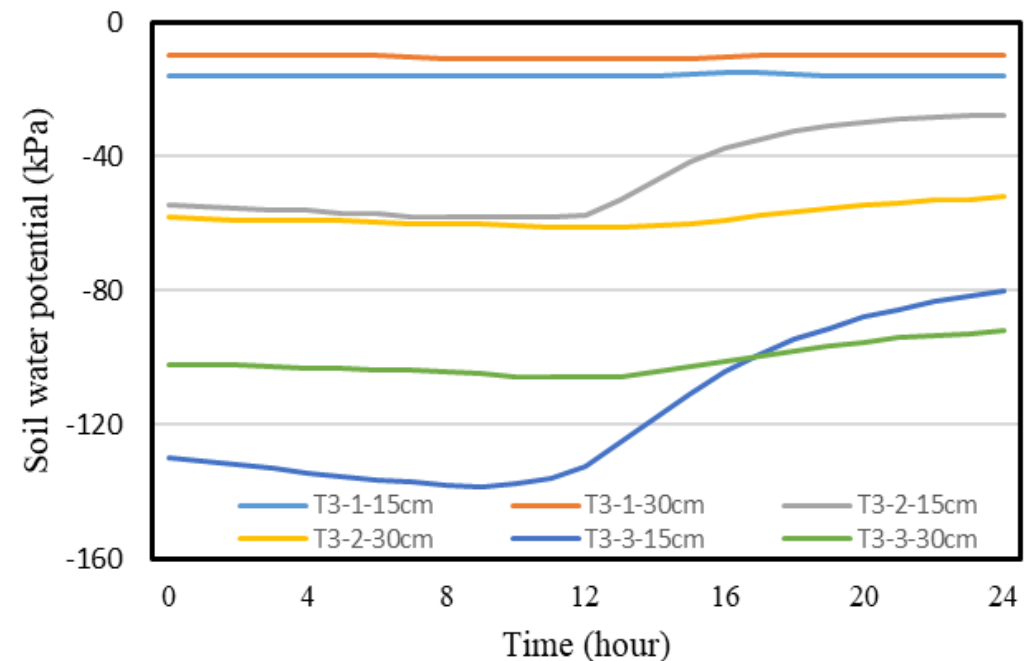
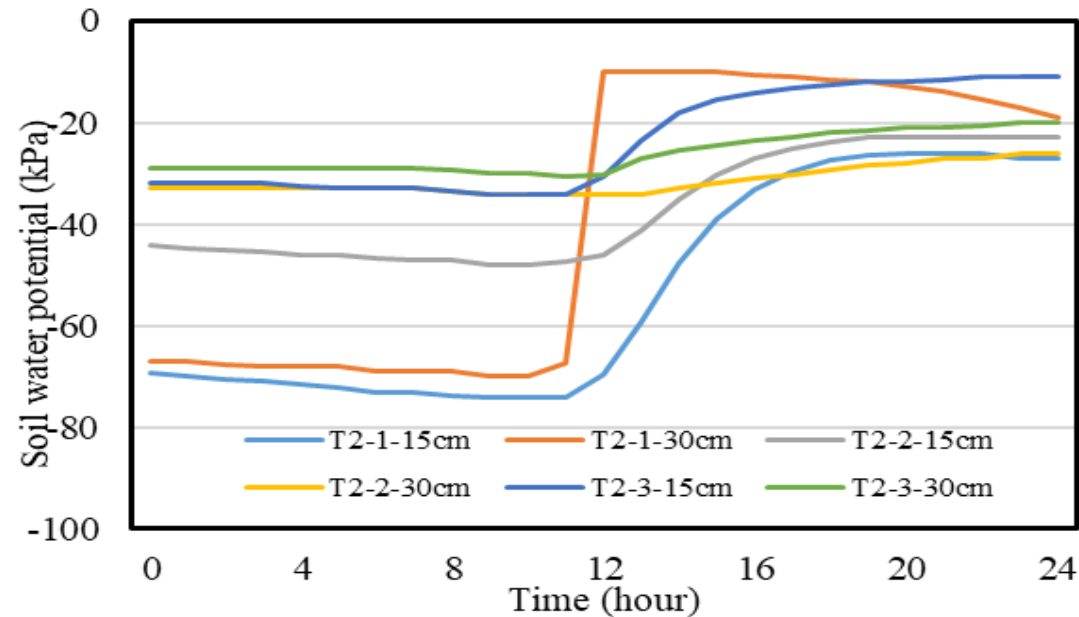
Results: Soil moisture monitoring with IoT system

- Data record from 11/20/19. Irrigation on Day 6 11:50 AM
- Soil water potential (T2&T3) day 1-20



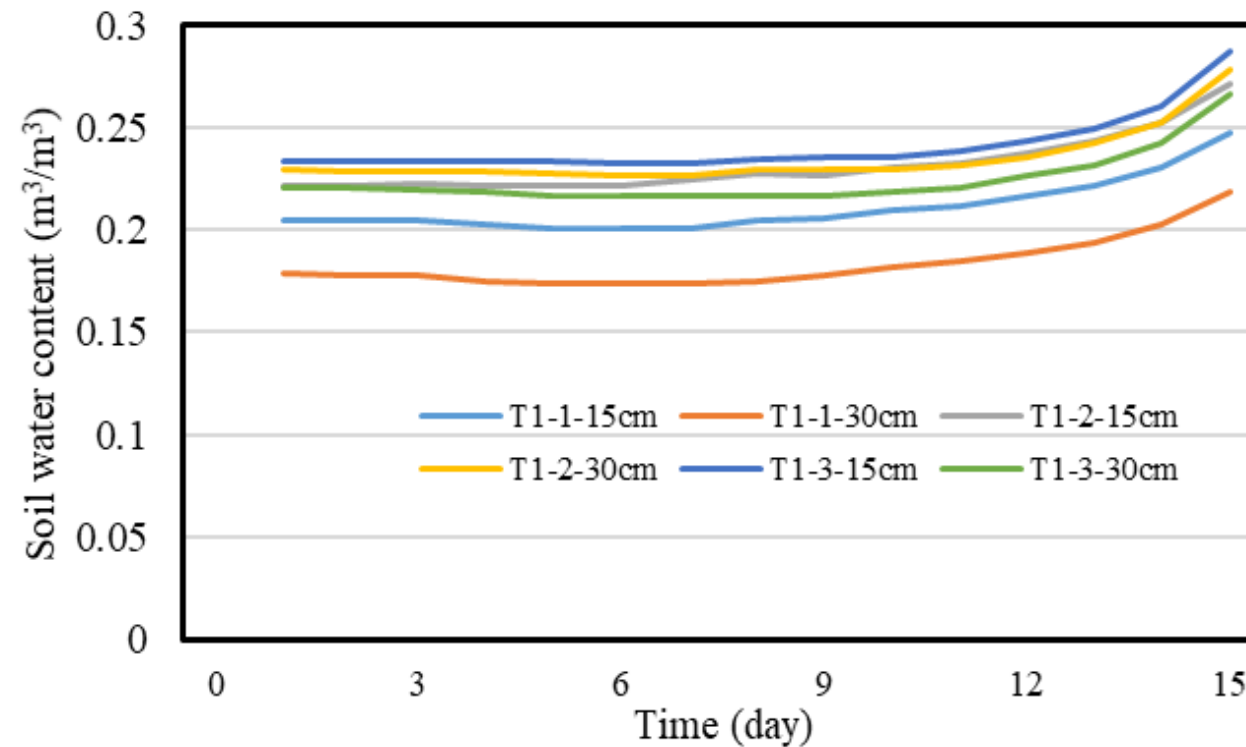
Results: Soil moisture monitoring with IoT system

- Data record from 11/20/19. Irrigation on Day 6 11:50 AM
- Soil water potential (T2&T3) 0–24 h on Day 6



Results: Soil moisture monitoring with IoT system

- Data record from 11/20/19. Irrigation on Day 6 11:50 AM
- Soil water content (T1) day 1-15



Conclusion

- The IoT system worked well in general.
- 4.3% signal loss with 300 m distance. Caused by the office wall obstacle, long distance, and gateway performance.
- Enough batteries for two months
- Issues on soil water content sensors

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Thank you!

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