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SMART AND EFFICIENT IRRIGATION SYSTEM USING WIRELESS SENSOR NETWORK AND IoT

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Abstract

A smart and efficient irrigation system is being proposed which minimizes water consumption for commonly cultivated plants. The irrigation system has a wireless sensor network consisting of soil moisture and temperature sensors, placed in the irrigated land. The system also has a wireless control unit that will receive the sensor information from the wireless sensor network, send control signals to the relays on the water taps, and also wirelessly transmits sensor data to a web server. An algorithm is proposed to compute the exact amount of water needed for irrigation which uses the sensor data received from the wireless sensor network. The wireless control unit controls the water tap to release the amount of water needed for irrigation. The control unit also sends the sensor data to a web server using Wi-Fi and the Internet. A web application is used to read and inspect the sensor data from the server and for scheduling the irrigation through control commands. The system will be used for testing some commonly cultivated plants in a particular geographical location and is also intended to be used for other geographical locations. The software developed takes into account the plant and soil type, plant growth stages, plant evaporation data, soil conditions, and effective rainfall. This software will also determine the most suitable irrigation schedule for a particular crop. The system will be more useful in locations where water is scarce.

Keywords : Mha, IoT, WSU, WCU, WSN, RCU, Wi-Fi

I. Introduction

Ground and River water resources are used by human beings, industry, agriculture, etc. Among these, the agriculture sector uses around 85% of this water resource worldwide [XI]. With a growing population, there will be a simultaneous increase in water demand for all the sectors in the coming years. Hence, optimal usage of water for irrigation will be a great relief for many other sectors, especially in the areas suffering water scarcity and having vast cultivated lands and also significant domestic and industrial consumption. Over the years many methods were used for saving and management of irrigation water, mentioned below:

(a) Irrigation scheduling based on canopy temperature distribution of the plant, which was acquired with thermal imaging [XXIII].
(b) Scheduling irrigation of crops and optimize water use using a crop water stress index (CWSI) [III] and empirical CWSI [XXI].
(c) Calculation of CWSI using infrared canopy temperatures, ambient air temperatures, and atmospheric vapor pressure deficit values [XXIV]
(d) Calculation of the volumetric water content of the soil using dielectric moisture sensors [XIII].
(e) Use of remote canopy temperature. Automatic irrigation was triggered once canopy temperatures exceeded the threshold values [XVIII]
(f) Estimating plant evapotranspiration (ET) as in [XVII], [XXII]. [XIV]
(g) An electromagnetic sensor to measure soil moisture [VIII]
(h) Using soil sensor and an evaporimeter, which allows for the adjustment of irrigation to the daily fluctuations in weather or volumetric substrate moisture content [XVII]
(i) Use of Wireless Sensor Network (WSN) and a decision support software, driving an irrigation machine consisting of controllable sprinkler nozzles [XXVI], [XXVII].
(j) A data acquisition system is deployed for monitoring soil moisture and soil, air, and canopy temperature measurement in cropped fields [II].
(k) WSN and a weather station for Internet monitoring of drainage water using distributed passive capillary wick-type lysimeters [XXV].
(l) Using hybrid architectures [XVI].
(m) Using WSN's and microcontrollers and communication technologies for real-time monitoring (for a wide range of applications) [VII], [IX].

The proposal in this paper is applicable for both Sprinkler Irrigation System and Drip Irrigation System. There are several advantages of Sprinkler and Drip Irrigation Systems and overall Drip Irrigation has certain advantages over Sprinkler Irrigation.

Though the drip-irrigated area is about 3.60 Mha, it represents about 1 % of the world's total irrigated area. Given the worsening water scarcity and rising water costs, there is tremendous scope for increasing the use of the drip system in the world. About 40% of the world's food now comes from 17 % of the irrigated land of about 2553 Mha. The erratic rainfall pattern also plays a significant role in the adoption of different irrigation techniques. Irrigation costs vary from region to region. It is very high in Africa and low in South Asia. Also due to the scarcity of water and the higher cost of irrigation infrastructure, it is essential and necessary to economize the use of water and at the same time increase the irrigation produce per unit area. This could be achieved only by large-scale adoption of an efficient irrigation system. There are several advantages of an efficient irrigation system described in [XII].

The net irrigated area in India is about 56.5 Mha, through tanks 3.1 Mha, through canals 17.1 Mha, through tube wells 17.9 Mha, through other wells 11.9 Mha, and through other sources including drip and sprinkler irrigation 6.5 Mha. Per capita, water availability is decreasing in India. It was 5300 m^3 during 1955 and got reduced to 2500 m^3 during 1990 and it is estimated that during 2025 it will be 1500 m^3 only. Considering this decreasing trend of water availability and increasing population, industrialization, agriculture, etc. precious water resources should be used judiciously [I] [IV]. Irrigation aims to restore soil water in the root zone to a level at which the plant can fully meet its evapotranspiration requirements. The degrees of soil water deficit, soil type, crop type, climatic/atmospheric conditions, geographic location, etc. Irrigation scheduling depends on the soil, crop, atmosphere, irrigation systems, and operational factors. Irrigation scheduling techniques can be based on soil conditions, plant indices, climate approaches, critical growth stage approaches, and plant water status [V] [VI]. In the conventional irrigation system, there is a fixed duration for the irrigation scheme. This results in fixed usage of water undermining the real requirement of the plants. The farmer just turns ON the water pump for a fixed duration without assessing the exact amount of water needed. Over Irrigation wastes water, energy, and labor and also brings the plant nutrients below the root zone. And, thus reduces soil aeration and yield. Irrigation leads to plants stresses and also results in yield reduction. The goal of an effective scheduling program is to supply the plants with sufficient water while minimizing losses to deep percolation or runoff.

The amount of water to be applied is determined by (1) soil texture (2) soil structure/water penetration (3) depth of effective root zone of the soil (4) the crop grown (5) the stage of development of the crop. Soil consists of different types of matter of different sizes and pore spaces. **Soil texture** refers to the type and composition of the soil contents: sand, silt, and clay. **Soil structure** defines the number of pores in the soil and the capability to hold water and air. The factors affecting the irrigation depends on (i) Plant (ii) Soil (iii) Climate (iv) Crop Management Practises [V].

Following are some of the Terminologies in Irrigation: Field Capacity, Wilting Point, Available Soil Moisture, Refill Point, Root Depth, Soil Water Storage Capacity, Plant/Crop Factor, Daily Plant/Crop Water Use, Effective Water Available in Soil, Irrigation Interval which is explained in [V] [VI].

Soil Water Storage at the end of a particular day = Field capacity – Refill point – Accumulated daily water use.

II. Methods for Irrigation Scheduling [V] [VI]

(1) Scheduling based on Water Balance Method

The water storage in the soil must always be balanced against plant water use. Table 1 below gives an example of this method for calculating the next irrigation day.

Table 1: Example calculating irrigation frequency

Date	Evaporation (mm)	Crop Factor	Crop Water Use (mm)	Effective Rainfall (mm)	Soil Water Storage (mm)
1/10	**Previous Irrigation**				**50.0**
2/10	5.3	0.9	4.8	0	45.2
3/10	13.0	0.9	11.7	0	33.5
4/10	11.1	0.9	10.0	0	23.5
5/10	16.1	0.9	14.5	0	9.0
7/10	0.2	0.9	0.2	5	13.8
8/10	15.0	0.9	13.5	0	0.3
9/10	10.0	0.9	Irrigate Today		

(2) Scheduling based on Climatology

Different methods in the Climatological approach are (i) Irrigation Water / Cumulative Pan Evaporation (IW/CPE) Ratio Method and (ii) Pan Evaporimeter Method.

IW/CPE Ratio Method: When the cumulative pan evaporation (CPE) reaches a predetermined value, irrigation is carried out. The amount of water given at each irrigation ranges from 4 to 6 cm. The most common being 5 cm irrigation. Generally, irrigation is given at 0.75 to 0.8 ratios with 5 cm of irrigation water. With 5 cm of Irrigation water and a ratio of 0.78, irrigation is given when CPE reaches 6.41.

Pan Evaporimeter Method: For a given location and crop, it has been observed that a close relationship exists between the rate of evaporation by crops (ET) and the rate of evaporation (E) from a well-located Standard Evaporation Pan. The ratio between Evapo-Transpiration of plants and Evaporation from Standard Pan is about 0.5 to 1.3 after the establishment of the crop.

(3) Scheduling based on Soil Moisture

Soil Moisture Tension, Available Soil Moisture Depletion (ASMD): When the soil moisture level/tension in a specified root zone is depleted to a particular level, it is replenished by irrigation. ASMD levels are different for different crops. Soil Matric Potential (SMP) is another realistic criterion for measuring soil water availability to plants as it constitutes the force with which water is held by soil matrix (soil particles and pore space) and is measured by tensiometer.

(4) Scheduling based on Plant Conditions or Plant Physiology

Leaf Water Potential (LWP), Stem Water Potential (SWP): These allow measuring the plant water status during the day. Monitoring leaf turgor pressure, trunk diameter, and sap flow are another way of scheduling irrigation. Specific plant-based methods include the use of dendrometry, fruit gauges, and other tissue water content sensors. Others include measurements based on growth, sap flow, and stomatal conductance using infrared thermometry and thermography for scheduling. Crop Water Stress Index based on Canopy Temperature and Vapor Pressure Deficit could also be used for monitoring plant water status and planning irrigation scheduling.

(5) Scheduling based on Critical Growth Approaches

The critical stages of the plant growth are carefully monitored so that the moisture stress level does not reach the irrecoverable yield loss. One or more plant growth stages could be critical.

Table 2: Critical Moisture-Sensitive Stages for Crops

Sr. No.	Crop	Important Moisture-Sensitive Stages
1	Rice	Panicle Initiation, Flowering
2	Wheat	Crown Root Initiation, Jointing, Milking
7	Ground Nut	Rapid Flowering, Pegging, Early Pod Formation
8	Red Gram	Flowering & Pod Formation
9	Green Gram	Flowering & Pod Formation
10	Black Gram	Flowering & Pod Formation
11	Sugarcane	Formative Stage
12	Sesamum	Blooming stage to Maturity
13	Sunflower	Two weeks before & after flowering
14	Safflower	From rosette to flowering
15	Soybean	Blooming & seed formation
16	Cotton	Flowering & Ball Formation
19	Potato	Tuber Initiation to Tuber Maturity

III. Proposed Smart and Efficient Irrigation System

In the proposal presented in this paper, the amount of water needed for irrigation is calculated well beforehand, by analyzing the soil moisture and temperature levels and the characteristics of the crop, soil, field environment, geographic location, season, etc. This paper presents a **Smart and Efficient Irrigation System** using Microcontrollers, Wireless Sensor Network (WSN), Wireless Control Unit (WCU), Wi-Fi, and the Internet. Each WSN is made up of several Wireless Sensor Units (WSU's). The aim of this system is for optimal usage of irrigation water daily and hence leading to enormous savings of water over a period of time.

Each WSU consists of a microcontroller, wireless transceiver module (nRF24L01), and sensors (soil moisture and temperature sensors that are placed within the soil at the root level). The microcontroller in the WSU reads the sensor data and sends these data wirelessly through the wireless transceiver module to the WCU. Additional WSU's can be used for reading the air and canopy temperatures for finer estimation of the water requirement of the plants. Each WSU is placed at the most suitable location in the field which is different from other WSU's so that the entire irrigation field is covered. The irrigation zone can be subdivided into the number of regions which equals the number of WSU's in the WSN. And each WSU can be placed at the center of each sub-region. All the WSU's collectively form a WSN. Care has to be taken that WCU falls within the transmitting range of the nRF24L01 modules in each WSU (up to 100 meters). For larger fields where the WCU falls beyond the transmitting range of WSU, intermediate WSU's can be used for re-transmitting the sensor data to WCU. In this way, one WSN can be used even for larger irrigation fields (several acres). The WCU can lie within the WSN (within the irrigation zone) or outside it (outside the irrigation zone). In general, WSU performs two activities: (i) Reading the sensor data from its sensors and transmit them to WCU if it is within the transmitting range (ii) Reading the sensor data from the neighboring WSU and transmit it to the WCU if the WCU is beyond the transmitting range of the neighboring WSU.

The WCU consists of a microcontroller, wireless transceiver module (nRF24L01), relay module, and Wi-Fi module. The WCU uses the wireless transceiver to receive the sensor data from all the WSU's. WCU and WSU communicate using the wireless transceiver module nRF24L01. The microcontroller in the WCU uses the relay on the water tap to switch on/off the water flow. The rate at which the water flows is mainly determined by the irrigation set up made up of pump, taps, pipes, and nozzles and is known in advance. The amount of water for irrigation is computed using a scheduling algorithm and the duration of water flow is calculated by dividing the amount of water required by the water flow rate. This gives the amount of time the relay needs to be switched ON for irrigation.

The WCU also transmits all the field data to a web server/cloud through the Wi-Fi module and the Internet.

The Internet connection

- allows periodic transmission of field data from the WCU to a database server/cloud for storage.
- allows offline and real-time data inspection of field data graphically using a remote web-based application (RCU).
- facilitates the use of irrigation scheduling schemes in the RCU based on the available field data from the server/cloud.
- allows the web application to send control commands to the WCU for irrigation scheduling /re-scheduling based on the analysis performed on the available data.
- allows for remote control of the irrigation system through the web application using start and stop commands

Figure 1 shows the Block Diagram for the Proposed Irrigation System

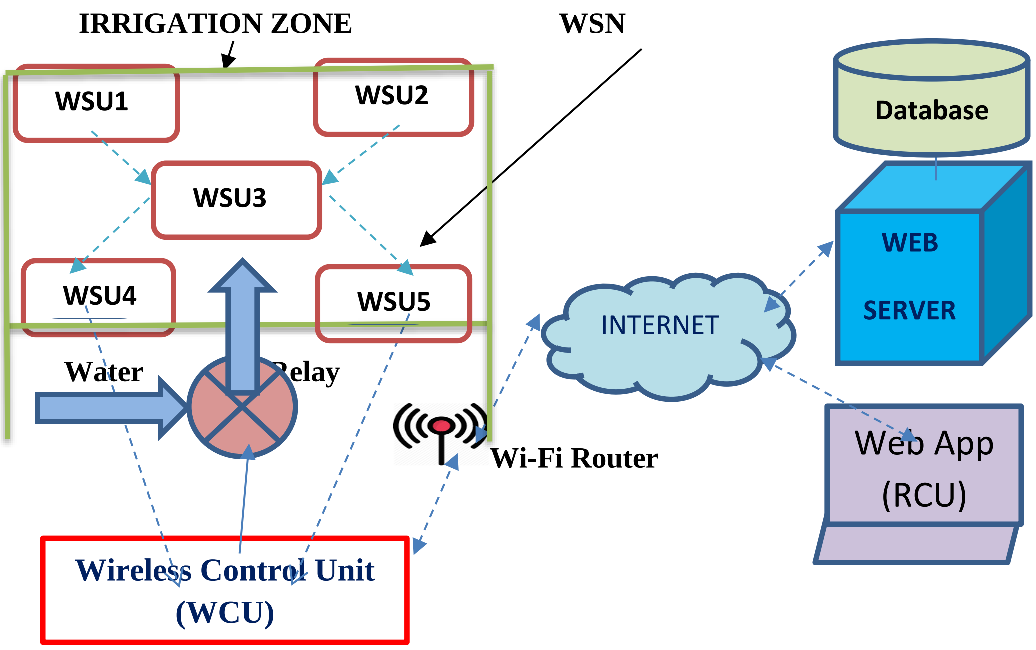

Fig. 1: Proposed Smart and Efficient Irrigation System

Daily Irrigation Water Estimation Algorithm

Input Data

1. Type of plant and soil
2. Water Flow Rate of the irrigation system. This is fixed for a given irrigation system with fixed pipelines.
3. Plant Growth Stage, Evaporation Data, Crop Factor, Effective Rainfall. These are available from the local horticulture advisor.

4. Table of **Soil Moisture Level** versus **Water Per Square Meter** needs to be stored for the computation of Soil Water Storage.
5. Soil Water Storage at the beginning of the previous day. This is available from the estimation algorithm of the previous day.
6. Pan Evaporation data from a Standard Pan Evaporimeter.

Algorithm

1. Estimate Soil Water Storage **Threshold Level** taking into account the type of soil and plant and critical growth stage of the plant. This will be a fraction (10 to 20 %) of the Soil Water Storage (Soil/Field Capacity)

2. Read Soil Moisture Level and Temperature from all the WSU's (This takes into account the rainfall). The nRF24L01 module in the WCU receives the sensor data from the WSU's NRF2401 modules periodically. The period can be set from few seconds to few minutes.

3. Estimate the Soil Water Storage from the Soil Moisture Levels and Temperature obtained from the WSU's. Typically, X % of soil moisture will translate into Y mm of water per sq. the meter of soil. This data can be obtained from the **allowable reduction** in the quantity of water for different soil groups. The data of moisture versus water per sq. the meter can also be obtained by repeatedly experimenting on a given field from a lower moisture level to the field capacity. The data needs to be stored in a table and this table can then used for reading Soil Water Storage from the field Soil Moisture Level.

4. Estimate the previous day Plant Water Use from the Evaporation Data and Crop Factor. If there is rainfall, Evaporation can be approximated to zero or a low value.

   Plant Water Usage (Yesterday) = Crop Factor * Evaporation
   Soil Water Storage (Today) = Soil Water Storage (Yesterday)
   – Plant Water Usage (Yesterday)
   + Effective Rainfall (Yesterday)

   The Soil Water Storage estimated in the steps (3) and (4) should match

5. Compare the calculated **Soil Water Storage** with the **Threshold Levels** and take the desired action. Threshold Levels are computed in Step 1.

   If (Soil Water Storage reaches the Threshold Value)
   {
   A. Compute Irrigation Water as follows:

   Irrigation Water, IW = Plant Water Usage from the last irrigation day till the current irrigation day

The Plant Water Usage for each day is estimated in Step 4.
Refer to **Table 2** for estimating Plant Water Usage.

B. Compute the Duration for which the water taps need to be ON

Duration = IW / (Water Flow Rate);
Note: Water Flow Rate is the Input Data

C. Switch ON the water tap relay

D. Wait for the period equal to Duration

E. Switch OFF the water tap relay

F. WAIT until the next day

```
}
else
{
    Wait for a small duration (1 to 10 mins)

    if  (End of Day)
    {
        WAIT until the next day
    }
    else
    {
        Go to Step 2
    }
}
```

Arduino Implementation for the System Shown in Figure 1

The sample implementation is for a smaller field where the WCU is within the range of all the WSU's (< 100 meters). The method can be extended to larger field areas by making the intermediate WSU's as both receivers and transmitters.

(1) Wireless Sensor Unit's

```
#include <SPI.h>            // SPI library to communicate with nRF24L01
#include <RF24.h>           // from  https://github.com/tmrh20/RF24/
#include <nRF24L01.h>       // from https://github.com/tmrh20/RF24/

const int pinCE = 7;   // PinCE low means standby mode and high means active mode
const int pinCSN = 8; // Pin used to tell the nRF24 whether command or message

RF24 radio(pinCE, pinCSN);                 // Create nRF24 object

uint64_t address1 = 0xA1A2A3A4B1LL; // for nRF24L01 module in WSU1
uint64_t address2 = 0xA1A2A3A4B2LL; // for nRF24L01 module in WSU2
uint64_t address3 = 0xA1A2A3A4B3LL; // for nRF24L01 module in WSU3
uint64_t address4 = 0xA1A2A3A4B4LL; // for nRF24L01 module in WSU4
uint64_t address5 = 0xA1A2A3A4B5LL; // for nRF24L01 module in WSU5

void setup()
{
    // Initialize the Serial and the Radio Device at the WSU
    // The appropriate Radio Device address should be used
    // Each Radio Device as a unique address as given above
    Serial.begin(115200);                    // Start serial communication
    radio.begin();                           // Start the nRF24 module
    radio.setPALevel(RF24_PA_LOW);  // RF24_PA_HIGH for "long range"
    radio.setDataRate(RF24_250KBPS); // Set data rate to 250kbps
    radio.setChannel(100);                  // Set the Transmitter Frequency (2.4)
    radio.openWritingPipe(addressj);      // Open Pipe for writing, j =1 or 2 … or 5
    radio.stopListening();                  // Go into transmit mode
```

```
}

void loop()
{
    // Read and Transmit Soil Moisture Data for every 1 second
    // Each loop is delayed by 1000 milliseconds (1 second). The choice is flexible.
    // The Receiver Read cycle should be multiple of Transmitter write cycle
    int moisture_adc;
    moisture_adc = analogRead(A0);   // Moisture Sensor to PIN A0 of  Arduino
    radio.write(&moisture_adc, sizeof(moisture_adc));
    delay(1000);
}
```

(2) Wireless Control Unit

```
#include <SPI.h>                    // SPI library to communicate with nRF24L01
#include <RF24.h>                   // from  https://github.com/tmrh20/RF24/
#include <nRF24L01.h>               // from https://github.com/tmrh20/RF24/

const int pinRelay = 5;// Pin used for Relay on Water Tap
const int pinCE = 7; // PinCE low means standby mode and high  means active  mode
const int pinCSN = 8; // Pin used to tell the nRF24 whether command or message
byte pipe = 0;                              // Pipe number
byte flag = 0;                              // Relay Flag (0 means OFF, 1 means ON)
RF24 radio(pinCE, pinCSN);                  // Create nRF24 object
uint64_t address1 = 0xA1A2A3A4B1LL;      // for nRF24L01 module in WSU1
uint64_t address1 = 0xA1A2A3A4B2LL;      // for nRF24L01 module in WSU2
uint64_t address1 = 0xA1A2A3A4B3LL;      // for nRF24L01 module in WSU3
uint64_t address1 = 0xA1A2A3A4B4LL;      // for nRF24L01 module in WSU4
uint64_t address1 = 0xA1A2A3A4B5LL;      // for nRF24L01 module in WSU5
```

```
void setup()
{
    // Initialize the Serial and the Radio Device at the WCU
    Serial.begin(115200);                          // Start serial communication
    pinMode(pinRelay, OUTPUT);
    digitalWrite(pinRelay, HIGH );                 // If NC and C are used for relay
    radio.begin(); // Start the nRF24 module in WCU
    radio.setPALevel(RF24_PA_LOW);                 // "short range setting"
    radio.setDataRate(RF24_250KBPS);               // Set data rate to 250kbps
    radio.setChannel(100); // Set Channel Frequency
    // Open 5 pipes for Receiver to receive Transmitter Data (Max 6 pipes per
channel)
    radio.openReadingPipe(0,address1);
    radio.openReadingPipe(1,address2);
    radio.openReadingPipe(2,address3);
    radio.openReadingPipe(3,address4);
    radio.openReadingPipe(4,address5);
    radio.startListening();                        // Start listening
}

void loop()
{
    int dig, data[5];          // Used to store sensor data coming from transmit module
    float ave_moisture, moisture_level[5];
    // Read the Transmitter Data. Read the Soil Moisture Levels from all WSU's.
    // Looping 1000 times with a delay of 10 milli second in each loop
    for (int i = 0; i < 1000; i++)  // Loop for 10 seconds
    {
        delay(10);
        if (radio.available(&pipe)) // Determine pipe number with available data
        {
            radio.read(&data[pipe], sizeof(int)); // Read data from available pipe
```

```
    }
}
// Calculate Average Soil Moisture
ave_moisture = 0.0; // Calculate the average moisture level
for (int i = 0; i < 5; i++)  // Assuming 5 WSU's
{
    moisture_level[i] = 100.0 - ((data[i]/1023.0) * 100.0);
    ave_moisture += moisture_level[i];
}
ave_moisture = ave_moisture / 5.0; // Assuming 5 WSU's (Transmitters)
// Switch ON or OFF the relay
if (ave_moisture >= 70.0)            // Soil Water has reached field capacity
{
    // Turn Off Relay. Relay is turned OFF when the digital pin is HIGH
    digitalWrite(pinRelay, HIGH);   // Water Tap OFF
    // Wait until the next day. The program is restarted the next day.
    while(1);
 }
 else
 {
     // Turn On Relay. Relay is turned ON when the digital pin is LOW
     //  Switch ON the tap only once in the beginning (when flag = 0)
     if (flag == 0)
     {
         digitalWrite(pinRelay, LOW); // Water Tap ON
         flag = 1;
     }
 }
}
```

Web Server and Web Application

Linux Apache Server having enough disk space and database size is used for storing the field data. The server supports several languages like HTML, PHP, java-script, python, etc. cPanel web hosting control panel is used for graphical user interface with the server for managing and controlling files and databases.

The web application is available by entering the domain www.eiotlab.com in any browser. On the main page, the application name **IRRIG** needs to be entered for logging in. After this, the "**Irrigation Login Form**" appears. Enter the "**Username**" and "**Password**" and then click the Login tab. Then the "**Irrigation Main Page**" appears. Now by pressing the "**Irrigation**" Menu, a table is displayed with the current day field data showing (1) Time of the day (2) Moisture Level in % (3) Soil Water Storage (4) Evaporation Data (5) Temperature of the soil. Graphical display of each data versus time can be carried out by clicking the corresponding "**Display**" button.

The Web App can also be used for

(a) Performing Scheduling/Re-Scheduling for a given crop using the real-time data obtained from the WCU which are the various moisture and temperature levels in the field. And the offline data such as the soil type, soil fertility, crop growth stages/characteristics, type of season, environment status, geographical location. The environment status could be wind conditions, degree of sunlight, humidity, etc.

(b) Sending commands to the WCU like shut down, start irrigation with computed scheduling, restart the irrigation with new scheduling. The restart command will force the WCU to abandon the current scheduling and restart with new scheduling determined by the Web App.

Figure 2 below depicts the overall control operation

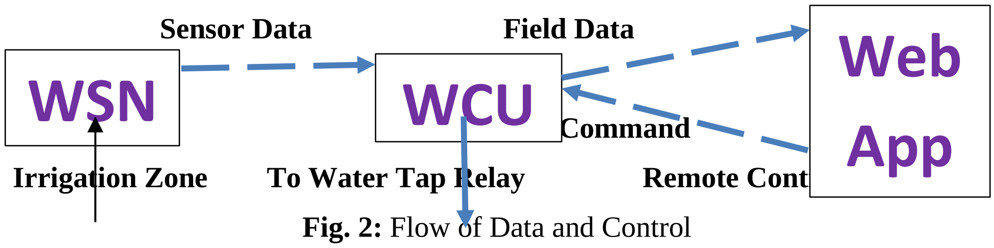

Fig. 2: Flow of Data and Control

IV. Conclusion and Future Scope

The proposed method has the following advantages over the existing methods:

(1) Consideration of several irrigation parameters to determine the amount of water for irrigation such as soil type, soil condition, plant type, plant growth stage, plant evaporation, environmental status. This will lead to the optimal usage of water by plants reducing the risk of more irrigation and also low irrigation.

(2) Coverage of large areas using a minimum number of WSU's. Each WSU can cover an area up to 5 acres and it requires very few WSU's to cover a large irrigation field of several acres.

(3) The unit cost of WSU and WSU is much less compared to other methods in references [VII], [IX], [XVI] [XXV], [XXVI], [XXVII]. Since each WSU covers a large area, the cost of implementation is further reduced.
(4) The WSN using the nRF24L01 is more efficient and cheaper than using Zigbee Wireless Sensor Network. Also, Zigbee (XBee X2C) has a smaller transmitting range compared to nRF24L01.
(5) Each WSU unit is small and compact and can be easily placed into the soil and can also be removed and reinstalled with new batteries without much difficulty.
(6) The reading and transmission of the sensor data from the WSU can be very less frequent (a few times in an hour). Hence, the majority of the time, the WSU and WCU can be operated in low power mode resulting in a huge reduction of battery consumption. Hence the batteries can last for several months.
(7) The system is very user friendly because the farmer just needs to restart the WCU once in a day. The WCU can also be controlled from the Web App thus reducing the number of visits to the field.

The WCU algorithm can be further enhanced or improved by considering additional parameters such as canopy temperature, air humidity, degree of brightness in the sunlight, wind conditions, plant growth rate, etc. These enhancements and modifications can also be incorporated in the Web App scheduler/re scheduler.

Conflict of Interest :

Authors decleared : No conflict of interest regarding this article.

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