

Boosting Irrigation using WSN with Blaney-Criddle: Indian Agriculture

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Abstract - Indian economy is basically depending on agriculture. Agriculture is known as backbone of India. More than 60 percent of the Indian population mainly depends upon agriculture. Agriculture uses 80% of available fresh water resources worldwide and this percentage will continue to be dominant the water consumption because of population growth and increased food demand[2]. The proposed system addresses the scarcity of water problem and the need of proper water management. This system is based on a model which performs efficient irrigation management by finding the appropriate schemes for rational utilization of water for irrigation. This system provides the trained model to take a proper decision about appropriate amount of required water for particular crop by considering different parameters like - zone, type of soil, temperature, humidity and expert data.

Key Words: WSN, Irrigation, Blaney_Criddle, Crop Evapotranspiration, Decision Support System.

1. INTRODUCTION

Many agriculture activities can be boost up using Wireless Sensor Networks. One of these activities is the regulation of the quantity of water in cultivated field. Throughout the world, irrigation is one of the main water consumers. All most 60 percent of all the world water taken from river, lakes, reservoirs and wells is used for the irrigation.

The Indian economy is mainly based on agriculture and the climatic conditions are isotropic and are not able to make full use of agricultural resources. The main reason is the lack of rain and scarcity of land reservoir water. And another very important reason of this is due to unplanned use of water due to which a significant amount of water goes waste.

Irrigation plays an important role in crops production. It is based on the farmers experience, an environmental conditions and soil properties but this procedure are labor expensive, time consuming, wastage of resources. Therefore adaption of technology for efficient utilization and saving of fresh water is required. Every single drop of water is important for human beings and should be used efficiently [3].

The irrigation with automated procedures in agriculture increases the productivity as well as quality of product. Thus fulfilling the ever increasing demand for healthy and inexpensive food around the world, Wireless sensor network has been used for rapid development in agriculture for

optimal use of land and water resources. Environmental monitoring using WSN in agriculture for collecting data and controlling irrigation will give the best crop condition, increases the product efficiency, decreases the cost and provide a solid base for farmers to adjust strategies at any time [4].

1.1 Irrigation

Irrigation is an artificial application of water to the soil. An irrigation system is a system that delivers water to an area where water is needed but not normally present in the required amounts. Generally, it is used for agriculture and landscaping purposes. The effectiveness of the irrigation is determined by a number of different factors, including the type of irrigation system and the conditions at its time of use. Additionally, irrigation also has other uses in crop production, which include protecting plants against frost, suppressing weed growing in gain fields and helping in preventing soil consideration. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed or dry and farming.

Types of Irrigation:

There are many Different types of irrigation systems, depending on how the water is distributed throughout the field. Some common types of irrigation system include:

- Sprinkler Irrigation System
- Drip Irrigation System
- Surface Irrigation Methods
- Furrow Irrigation
- Subsurface Irrigation Methods

1.2 Calculation of the Crop Water Need

- The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. In other words, it is the amount of water needed by the various crops to grow optimally.
- The crop water need always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favorable soil conditions (including fertility and water). The crop thus reaches its full production potential under the given environment.

The crop water need mainly depends on:

- **The climate:** In a sunny and hot climate crops need more water per day than in a cloudy and cool climate.
- **The crop type:** Crops like maize or sugarcane need more water than crops like millet or sorghum
- **The growth stage of the crop:** Fully grown crops need more water than crops that have just been planted.

The influence of the climate on crop water needs is given by the **Reference Crop Evapotranspiration (ET_o)**. The ET_o is usually expressed in millimeters per unit of time, e.g. mm/day, mm/month, or mm/season.

Methods to determine the ET_o

- Experimental, using an evaporation pan, or
- Theoretical, using measured climatic data, e.g. the Blaney-Criddle method

2. RELATED WORK

Many Irrigation Management system using WSN has been designed. Many survey papers [1] [2] [3] [4] explains about the usage of sensors for Irrigations . Each concepts has its own pros and cons. Disadvantages like Data Loss, Irrigation schedule can be delayed upto 2-3 days after heavy rain in open fields, large amount of power consumption many more, and none of these systems speaks about decision making system with the trained model. Actual requirement for the proposed system is the accurate model which provides the proper information to the farmer.

3. THE PROPOSED SYSTEM

3.1 System Architecture

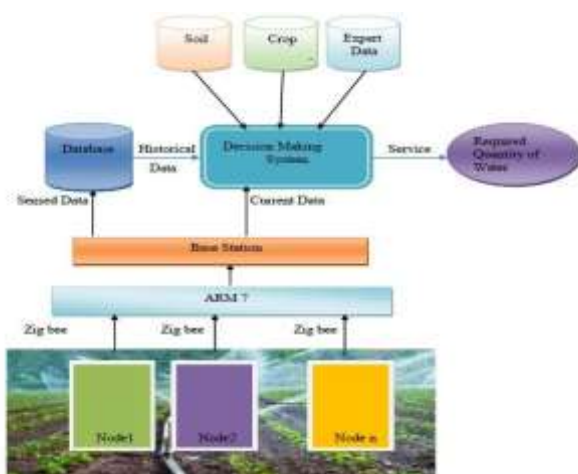


Fig-1: System Architecture

The System uses the sensors at the bottom layer. These communicate with ARM7 using Zigbee. The processed data will be passed to Base Station. Decision Support System makes use of Historical Data and also the Real-time data to take the proper decision.

3.2 Basic Idea

- Climate values such as humidity, temperature and soil moisture are considered to calculate the quantity of water that is needed for proper irrigation.
- This system consists of two subsystems. The first subsystem concerns with WSN which collects the data from cultivated field. The second subsystem involves the Trained Model called decision making system.
- Climate values such as humidity, temperature and soil moisture are monitored from efficient sensors and sensed data is transmitted to a base station.
- Calculate the water quantity for irrigation based on the data available in base station.
- Optimum decision is made by comparing current data with historical data.

The values such as humidity, temperature and soil moisture will be sensed from the sensors and those values will be stored in the database. The Sensed value will be retrieved and quantity of water will be calculated by using "Blaney_Criddle Method" and a message will be displayed to the user for proper irrigation

3.3 Blaney-Criddle Method

If no measured data on pan evaporation are available locally, a theoretical method (e.g. the Blaney-Criddle method) to calculate the reference crop evapotranspiration ET_o has to be used.. The Blaney-Criddle method is simple, using measured data on temperature only. It should be noted, however, that this method is not very accurate; it provides a rough estimate or "order of magnitude" only. Especially under "extreme" climatic conditions the Blaney-Criddle method is inaccurate: in windy, dry, sunny areas, the ET_o is underestimated (up to some 60 percent), while in calm, humid, clouded areas, the ET_o is overestimated (up to some 40 percent)[8]. And this is the reason for considering other parameter also like Humidity and Soil Moisture.

The Blaney-Criddle formula:

$$ET_o = p (0.46 T_{mean} + 8)$$

ET_o = Reference crop evapotranspiration (mm/day) as an average for a period of 1 month

T_{mean} = mean daily temperature (°C)

p = mean daily percentage of annual daytime hours

$$ET_o \times K_c = ET_{crop}$$

ET crop = crop evapotranspiration or crop water need (n)
 Kc = crop factor
 ETo = reference evapotranspiration (mm/day)

Both ET crop and ETo are expressed in the same unit: usually in mm/day (as an average for a period of one month) or in mm/month.

The crop factor, Kc, mainly depends on:

- The type of crop
- The growth stage of the crop
- The climate

3.4 Subsystem-I

Data Flow in Hardware

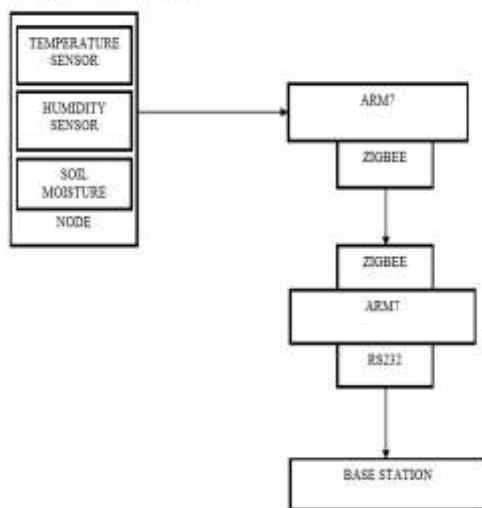


Fig -2: Data flow in Subsystem1

ARM(LPC2148), ZIGBEE(CC2500), RS232 and Sensors (Temperature Sensor, Humidity sensor and Soil Moisture sensors) are used to construct the first subsystem. This subsystem is responsible for sensing the environmental parameter like temperature, humidity and soil moisture. The sensed data is then passed to the base station where actual processing takes place.

3.5 Subsystem-II

This Subsystem consists of trained model to provide the appropriate result. This subsystem makes use of sensed data which includes both history and current sensed data and also uses the expert data to take the decision. By using the Blaney-Criddle formula, this subsystem will calculate the required quantity of water for a particular crop by considering the other parameters as type of soil, stage of crop and area.

Dataflow of Trained Model

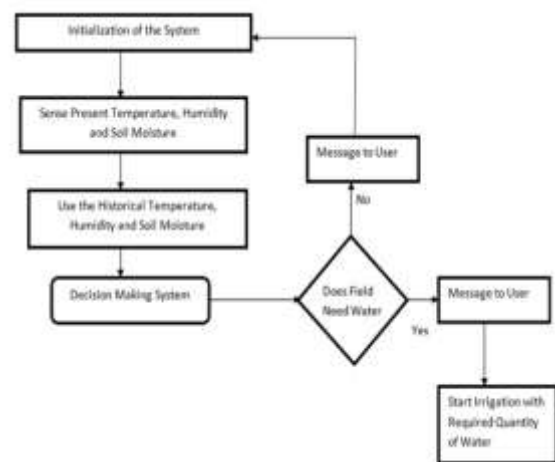


Fig-3: Dataflow in Subsystem2

4. IMPLEMENTATION



Fig-4: Irrigation Management

Proposed System is implemented and tested for different crops with different types of soil.

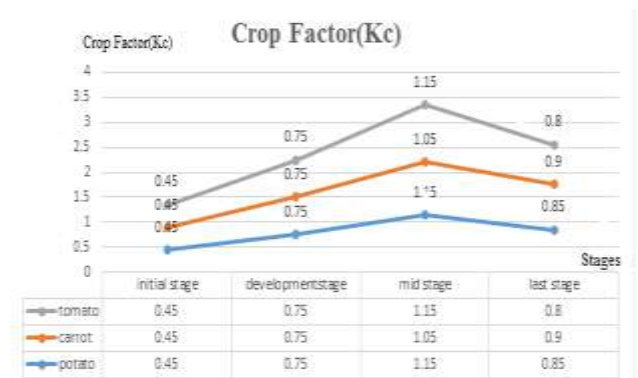


Fig- 5: Crop Factor(Kc)

The Figure:5 shows the Crop factor values for the crop at different stages. These are taken from the standard tables

to calculate the quantity of water and same values are depicted in the form of graph.



Fig -6 : Output Analysis.

The Figure:6 shows the Output values after execution of an application.

5. CONCLUSIONS AND FUTURE ENHANCEMENT

Every single drop of water is important for human beings and should be used efficiently. Environmental monitoring using WSN in agriculture for collecting data and controlling irrigation will give the best crop condition, increases the product efficiency, decreases the cost and provide a solid base for farmers to adjust strategies at any time. This system increases the productivity as well as quality of product, thus fulfilling the ever increasing demand for healthy and inexpensive food around the world. This system Calculate the water quantity for irrigation based on the data available in base station. Optimum decision is made by using “Blaney_Criddle Method”. Future enhancement may include Business Intelligent Process for boosting the irrigation by making it as Smart Irrigation.

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