AUTOMATED WATER MANAGEMENT IN RICE FIELDS

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INTRODUCTION

Oryza Sativa Indica, commonly known as Indian rice is a plant species which produces the cereal consumed by almost one third of the world's population as their staple food (Abdhullah *et al*., 2006). This sub species of rice is a seasonal plant which requires a huge amount of water and is usually grown in submerged fields for the major part of its life span. Therefore, it is of highest importance to have a reliable irrigation system and a specialized field in rice cultivation. In the special design of fields for rice cultivation, in order to retain the water, rice fields are separated into a set of plots and these plots are under- layered with mud. The water supply system takes a cascaded form so that the water flows to the lower level plots through the upper level plots and heavily utilizes the flow due to gravity. At the same time, the water in the rice fields has a tendency to dry up due to excessive sunlight or even due to being absorbed partially by the field floor itself. Therefore, the farmer is burdened with a responsibility to constantly monitor and refill the water up to the adequate levels by restructuring the plot walls' openings.

Meanwhile, in Sri Lanka too rice farming has been a main part of agriculture. To cater for its ever growing population's demand, the fast and efficient production methods have been preferred. Use of fertilizer, chemicals as insecticides and pesticides and also the use of genetically engineered rice varieties have been some of these techniques. Though this intensified agriculture increases the yield, it brings adverse effects too. Increased rate of cancer and kidney failures have been visible in areas where rice cultivation is done on a large scale. To minimize these adverse effects, recently, considerable interest is centered on the traditional methods of rice cultivation. These methods heavily rely on weather patterns as well as on varieties of rice which are immune to most of the insect attacks. Still, these varieties of traditional rice produce a reduced yield. It is a great challenge to meet a high yield while cultivating the traditional rice varieties with eco friendly methods. Precision agriculture (PA) (Zhang *et al*., 2002) is a handy technique where the right amount of resources is supplied at the right time in the right amount, to meet this tradeoff. In deploying the PA concept in rice fields, to supply the most important commodity, water, the farmer is overburdened with tight monitoring and control requirements. Although many electronic resource management systems for rice farming are available (Tran and Nguyen, 2006), none of them address controlling of water.

In this paper an electronic water management system is proposed with a remote management feature. This will provide a means of managing the water in rice fields in an efficient manner so that the high yield is retained even when the eco-friendly traditional methods and rice varieties are used. Moreover, this novel system greatly reduces the workload of the farmer and releases the requirement for him to be at the field for water management.

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METHODOLOGY

The proposed water management system consists of two main parts, namely a wireless sensor network to monitor the water levels over the rice field and a solenoid operated gate valve array based water supply system to manage the water flow to the field's plots (Figure 1). The water from a stream is stored in a reservoir from which the water is distributed to each and every plot in the field via polyvinylchloride (PVC) pipes using the gravitational natural flow. To have a better control of water flow, unlike in traditional rice fields, the plots are completely separated from other plots so that there is no water flow in between the plots. For the controlling of the flow of water to the plots, a set of gate valves are fixed in between the reservoir's outlet and the PVC pipes. This solenoid based gate valve array is controlled by a central electronic control circuit. Apart from these, the system is equipped with a remote control mechanism with the use of a global system for mobile communication (GSM) link which operates on a short message service (SMS) framework.

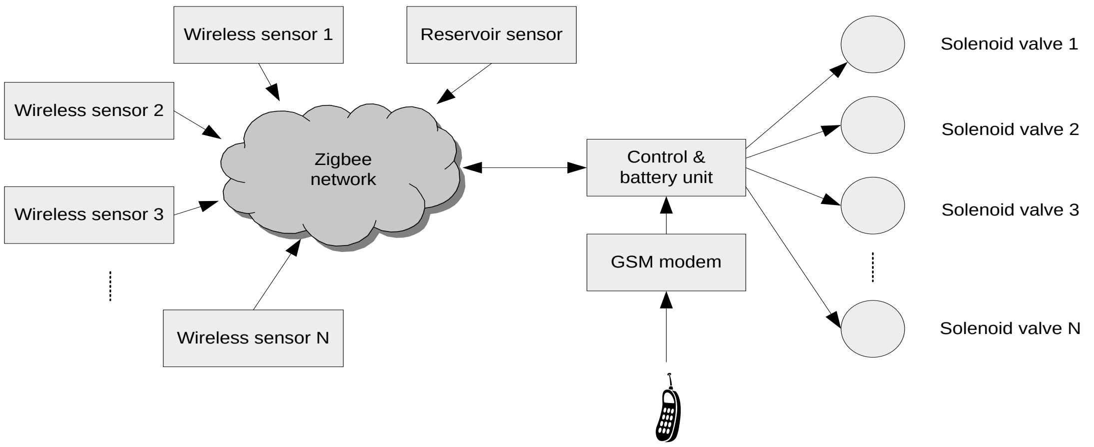

Figure 1: Block diagram of the proposed system

The basic building block of the sensor network, a sensor node, consists of a pair of electrodes which conducts a current upon contacting with moisture. This in turn produces a voltage at the output of the sensor circuit which is proportional to the amount of moisture in soil and once submerged in water it would provide a maximum current conduction. Depending on the seasonal requirement, the electrodes can be buried inside the soil or can be kept submerged in the water for detecting the moisture in soil/water (in the submerged field). Upon identification of the status of moisture in soil or water in the submerged plot, the same information is packetized with a unique packet identity and transmitted over a Zigbee network (Safaric & Malric, 2006). Each plot is equipped with a single sensor node while one sensor node is dedicated for monitoring the reservoir water level status.Note that this sensor node hardware including a solar panel to generate the required power is fixed to a plastic peg which can be generating the level crossing message. mounted accordingly so that the electrodes are placed at the needed measuring level (Figure 2)Further to this, as the wireless sensor network operates using a battery charged by solar power, it is seriously power constrained. Therefore, the sensor nodes transmit their information only upon required, saving power. Once a set threshold level crossing is detected, the node wakes up and generates a message with its node identification tag.

To avoid the level bouncing due to the ripples on the water surface, after a level crossing is detected a timer is started and the timer periodically checks for the level within next 15 minutes before.

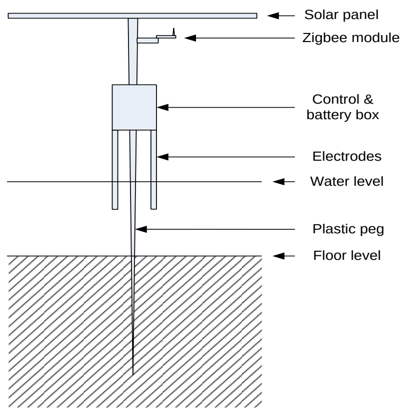

Figure 2: wireless sensor node

The message is relayed through the Zigbee based wireless sensor network. Upon receipt of this "low water level" message at the central control node, the control circuit interprets the message and checks for the availability of water in the reservoir and then activates the respective solenoid to release the water. During this control process, the central control unit stores the status of different plots' water levels, reservoir water level status as well as gate valve open/close status in a local database.

The employed SIMCOM203000 GSM modem (Texas Instruments, 2012) accepts SMS messages from the famer's mobile and can return a list containing the water level status and the gate valve status through SMS. Furthermore, upon opening a certain gate valve, system starts a counter and either upon the expiration of the timer in 15 minutes or upon detecting a level crossing, the corresponding valves are closed. If the timer expired without a crossing detected, it generates an error message SMS and forward the same to the farmer. On the other hand the farmer can command the control circuit to issue open/close a certain solenoid forcefully by an inward SMS.

TEST RESULTS AND DISCUSSION

To verify the accuracy of monitoring the moisture content in the field, the voltages generated at the output of the sensor was investigated and it clearly shows a linear behavior (Figure 3).

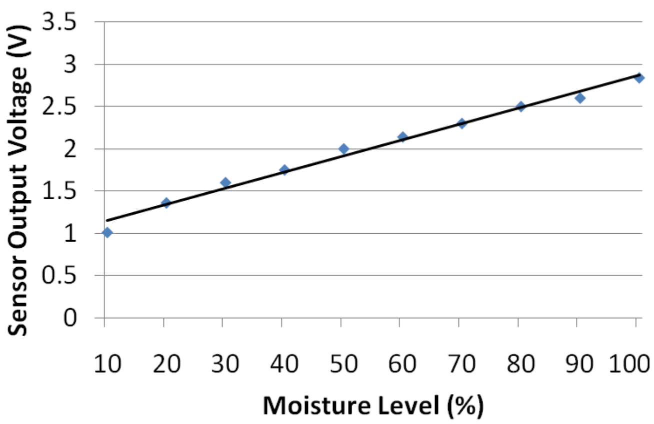

Figure 3: Moisture sensor performance

In order to verify the consistency of water management, a prototype system was deployed in one plot of a two plot rice field. In this test, two nearly identical $3m \times 4m$ plots were selected from a real rice field. Sensor electrodes were placed just touching the wet floor and the threshold was set to 90%. The system was operated for 24 hours on a non-raining day and the other plot was not controlled. The moisture level readings were recorded as in Table 1.

It clearly shows that the implementation of the proposed water management system has maintained the moisture/water level in the rice fields.

CONCLUSIONS AND FUTURE WORK

A novel water management system has been proposed to manage and maintain the water levels in rice fields automatically. The remote management feature provides the famer the ability to monitor the water management process from a remote location. This is a very handy system for a busy farmer managing multiple rice fields at different locations.

Table 1: Soil moisture level

Time (hrs)		00.00	01.00	02.00	03.00	04.00	05.00	06.00	07.00	08.00	09.00	10.00	11.00
Moisture Level (%)	Without the system	100	100	100	100	100	100	100	100	100	100	90	90
	With the system	100	100	100	100	100	100	100	100	100	100	90	100

Time		12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00
Moisture Level (%)	Without the system	80	80	70	60	60	60	60	60	60	60	60	60
	With the system	100	90	100	100	100	100	100	100	100	100	100	100

The proposed system is estimated to be incurring a capital cost of Rs.30,000 per acre on average where the operational cost is almost negligible. With the objective of eco-friendly rice cultivation retaining the high yield, this cost can be well justified.

This system does not facilitate a complete remote control. By introducing a set of sluice gates the water drain system can be altered so that the water level can even be reduced remotely. This would be a preferred feature to handle the excess amounts of water filled due to rain. Further, this system conveys the information with only a binary resolution as it conveys only whether the water/moisture level is above or below a certain reference threshold. However, if a sensor node can capture and convey more information such as the absolute water level, it would be very beneficial.

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