Irrigation Management System with micro-Controller Application

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***Abstract*— This paper presents optimized irrigation scheme using automatic water control for performing crop specific irrigation activities. Level of irrigation depends on soil moisture content and type of crop considered. Different crops need different soil moisture for optimum crop yield. For optimum crop yield, smart irrigation, knowledge of soil condition, and water requirement of crop is essential. Optimal usage of water reduces overall power consumption and optimizes usage of water reserves. Smart usage of irrigation system optimizes land area productivity and conserves nature by reducing overall involved emission & losses in conversion components. Low cost microcontroller like Arduino based interfacing unit, has been used in this paper to obtain low cost smart irrigation solution.**

Keywords*— microcontroller, smart irrigation, moisture sensor, water pumping motor, optimum water usage.

I. INTRODUCTION

Water security is an essential element of domestic as well as agricultural applications. Irrigation plays an important role in assuring quality crop production and contributes to socio-economic development a country [1]. It puts remarkable imprint on overall economic growth of a nation and socio-economic growth of the farmers [2]. Depending on the water distribution; conventionally, irrigation majorly depended on surface irrigation, sub-irrigation, or rain fed farming. It required high water table in the area, lacked intelligent water usage, and uneven water dispersion in cultivation area [3-5]. Uneven water dispersion in cultivation area is due to either excess water supply in area near canal or deficient water supply in area far from canal area. Such irrigation system faced worse results in elevated or uneven surface causing water log in low elevation region and deficient/no water in elevated regions. These shortcomings have been overcome to certain extent by localized irrigation like drip irrigation, sprinkler irrigation, center pivot irrigation, and lateral move irrigation [6]. These irrigation systems involved irrigation near plan region and needed comparatively lower water table. Irrigation must be as per crop demand as different crops need different level of moisture content for proper growth. Literature includes different irrigation techniques for improving overall crop yield [7-10].

Simulation and modelling of a crop yield; as a function of local weather, soil condition and crop management practices; is termed as crop modelling. It is generally defined as empirical models, statistical model, functional model, and mechanistic model [11]. Precision agriculture is a type of empirical model and depends on soil moisture, local meteorological conditions, fertilizer treatment & facility agriculture. Facility agriculture refers to intensive labour involvement to involvement of sophisticated modern agriculture technology. Precision agriculture mainly depends on climatic data like temperature & precipitation; Crops need favourable local condition and suitable soil moisture level to have proper growth [12-15].

Development of power electronics based equipments, remote communication units [16-19], renewable energy based generation [20-22] and sophisticated sensing sensors have renovated the monitoring and control of domestic applications, agricultural activities & environment alteration (to create suitable atmosphere for crop inculcation) [23-25]. This paper presents precision agriculture based crop model considering soil moisture and air temperature as key factors. Soil moisture has been sensed using homemade moisture sensor and micro-controller units acts as controller to ensure smart irrigation. Net water table requirement can be reduced using the presented system to keep the notion of 'more crop per drop'.

II. IRRIGATION SYSTEM IN-VOGUE

In the current irrigation technology scenario, most prevalent practices include surface irrigation, localized irrigation, and other crop-contextual irrigation. Crops need different amount of soil moisture content and surrounding temperature to nourish. Suitable irrigation can improve crop yield and need to be selected as per water table and economy involved in executing irrigation application.

A. Surface irrigation

It includes one of the most common form of irrigation methods and prevalent for past thousands of years. In this irrigation technique, water is distributed by gravity over the surface of the farmland. Surface irrigation can meet majority types of irrigation requirements. Three types of surface irrigation are generally used in practice, viz. level basin, border strip, furrow basin. These irrigation techniques are most suitable for staple crops. Flood irrigation is considered under surface irrigation, but due to uncontrolled distribution of water, it is genetically ineffectual.

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1) Level basin irrigation: It is generally used in small farmlands for close growing crops like paddy; and pastures like alfalfa, clover; etc. In this surface irrigation technique, water is applied from top end of the farmland to the whole farmland. In order to avoid water wastage, water runs off to pond after reaching the end of farmland, as shown in Fig. 1. In some countries, it is a basic type of irrigation system which is used in huge basis.

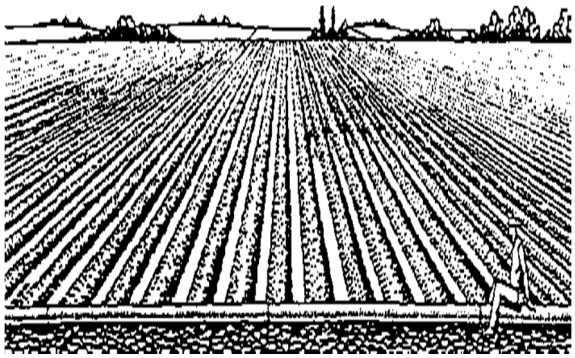

Fig. 1. Level basin irrigation

2) Border strip basin irrigation: It is generally an expansion of basin irrigation and land is shaped into strips levelled across the narrow dimension of length. During irrigation, water is drained at upper end of the border strip, and advanced down the strip, as shown in Fig. 2. Border strip basin irrigation is one of the most complicated irrigation methods in surface irrigation and suitable for crops is suitable to irrigate in this like barley, wheat, fodder, etc.

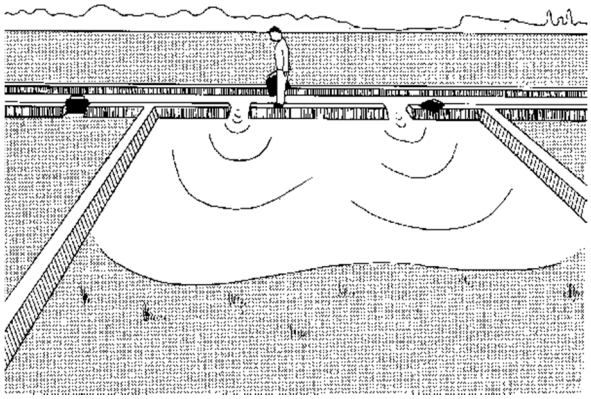

Fig. 2. Border strip basin irrigation

3) Furrow basin irrigation: It is generally used for cultivation of vegetables like tomato, potato, beans; row crops like maize, sugarcane, sunflower, soybean; and fruit trees like banana, citrus, grapes. In this scheme, water is applied in furrows rather than whole farmland filled with water. It involves more labour, but at the same time, it saves water and the crop is in indirect contact with water as shown in Fig. 3. It is also suitable for the plants or vegetables which are sensitive to pounded water.

Furrows are sloping channels, composed with the soil giving advantage to get water in root zone. Aside the stated advantages of the conventional irrigation techniques, it is associated with disadvantages like requirement of high water table, difficulty in welfare & dynamic use of fertilizers, and involvement of accountable manual labours.

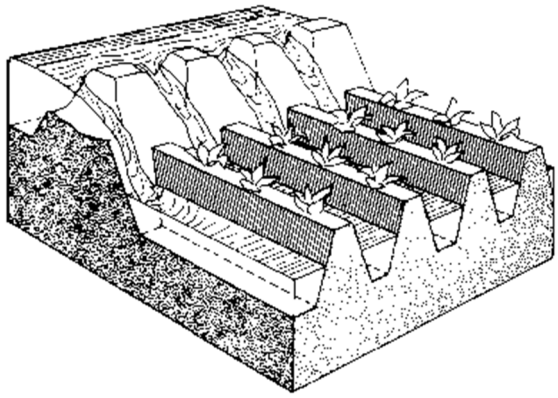

Fig. 3. Furrow basin irrigation

B. Micro irrigation methods:

It is a type of precision agriculture involving high water efficiency. Areas having low water table need efficient irrigation technique to ensure optimal utilization of available irrigation water. Commonly used practices in micro-irrigation methods involve three practices, i.e., (a) Drip irrigation (b) Sprinkler irrigation (b) sprinkler irrigation (c) channel irrigation

1) Drip irrigation: For the conservation of water, drip irrigation or trickle irrigation is one of the best technologies for watering gardens and trees. Water flow through a main pipe and divided into various pipes, as shown in Fig. 4. It allows water to drip slowly to the root of plants through valves, pipes, etc. The major disadvantage in drip irrigation is high cost compared to any of other irrigation system.

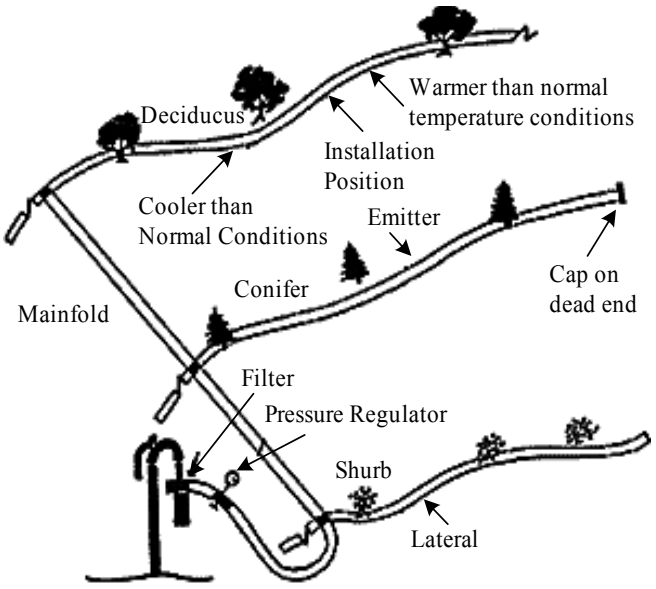

Fig. 4. Drip irrigation

2) Sprinkler irrigation: In this irrigation practice, delivery of water is like natural rainfall. It is most suitable in region having low water table, for nourishing cash crops, vegetables, and fruits. Pumped water is distributed through a system of pipes, through sprinklers. It is then sprayed into the air and valves are used to control the water flow as shown in Fig. 5. The major disadvantage in sprinkler irrigation is high installation cost and poor efficiency during high wind period.

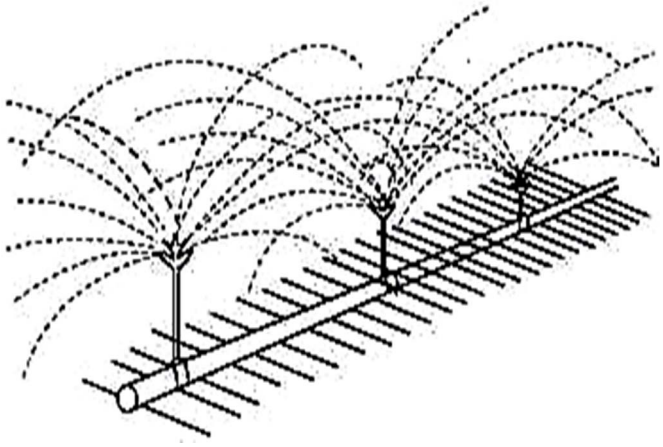

Fig. 5. Sprinkler irrigation

3) Channel irrigation: In this irrigation technique, large volume of water is used over large irrigation areas and is beneficial with large areas. It is cheaper and used for improving the crops growth as shown in Fig. 6. The major disadvantage in channel irrigation is wastage of water and large number of workers.

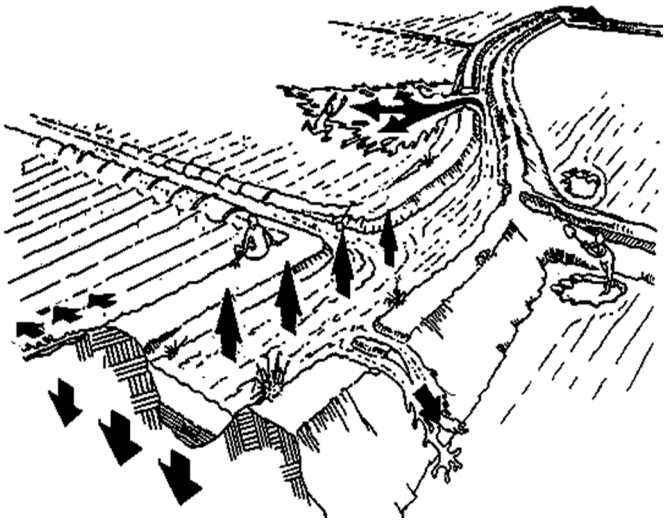

Fig. 6. Channel irrigation

C. Other crop-contextual irrigation:

Aside the above stated methods for assuring suitable irrigation for optimal crop yield, some crops need special treatment for proper crop growth. Crop contextual irrigation is especially used for maintaining crop dependent irrigation technology. For example, if any crop or plant of some tropical region need to be grown in sub-tropical region, proper water table need to be maintained. Manual maintenance of such condition is not possible if precision required is very high. In such cases smart crop contextual irrigation pattern can used efficiently.

III. Methodology

System consists of soil moisture sensor for obtaining soil humidity content, arduino micro-controller interface unit and knowledge based data like local meteorological condition & crop data base. Knowledge flow model of the application has been shown in Fig. 7.

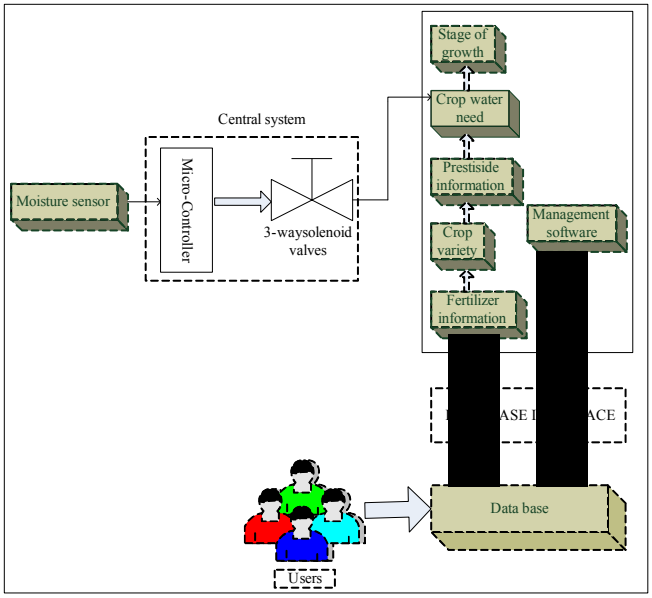

Fig. 7. Knowledge flow model of the application

A. Soil moisture Sensor

A low cost homemade soil moisture sensor has been used in this study. It consists of two 5 cm copper wires and a piece of polystyrene sheet. The copper wires are inserted at constant distance in polystyrene sheet, as shown in Fig. 7.

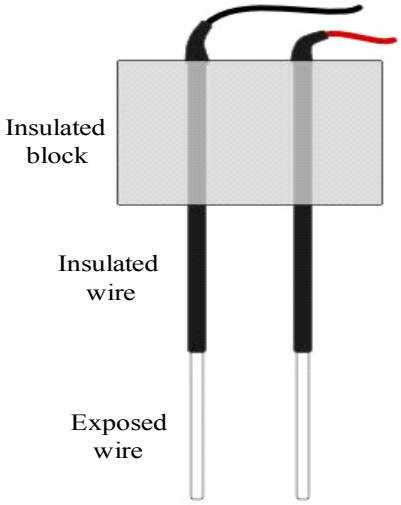

Fig. 8. Low cost soil moisture sensor

One ends of the copper wire which is to be inserted in to soil, are stripped off. To increase accuracy and range of arrangement, multiple numbers of sensors can be used. Output from the sensor is given as input to microcontroller interface unit.

B. Micro-controller

It is a small processor core integrated circuit used for automation of interfacing applications. In this paper atmega 328 based Arduino microcontroller interface has been considered. Arduino is an open-source prototyping platform based hardware-software interface, capable of achieving automation in motors, automobile engines, remote controlled applications and other embedded systems. Atmega 328 based Arduino microcontroller has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. Technical specifications of considered arduino interface considered in this paper, has been enlisted in table I. It can simply be put into action by connecting it to computer with a USB cable, power cable, AC-to-DC adapter, or battery.

TABLE I. TECHNICAL SPECIFICATION OF ARDUINO INTERFACE

Content	Specification
Microcontroller	Atmega328P
Operating Voltage	5 V
Input Voltage (recommended)	7 – 12 V
Input Voltage (limit)	6 – 20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 kB of which 0.5 kB used by boot-loader
SRAM	2 kB
EEPROM	1 kB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

The proposed system is based on micro-controller based automation for optimizing utilization of water resources and reducing labour cost in agricultural applications. System consists of arduino platform and functional components like moisture sensor & motor load. Arduino is a single board based hardware and IDE software interface for performing automation operations. Moisture sensor detects the humidity level of soil. Soil moisture and temperature predetermined range is set particularly for specific plants requirement, and according to that system is being operated. Motor load includes water pumps and involved accessories for supplying water to plants. Atmega328 Microcontroller automates water cycle based on information collected from humidity and temperature sensor. If soil moisture level is less than minimum defined threshold value, microcontroller acts to automatically trigger water pump to operate till sensor meets maximum threshold; as shown in Fig. 9.

Provision of generating overall activity report, intimation through mobile application to the user and facility to perform common switching application by remote mobile/computer, can be made for real time remote monitoring. Flowchart of the proposed monitoring and control system has been shown in Fig. 10.

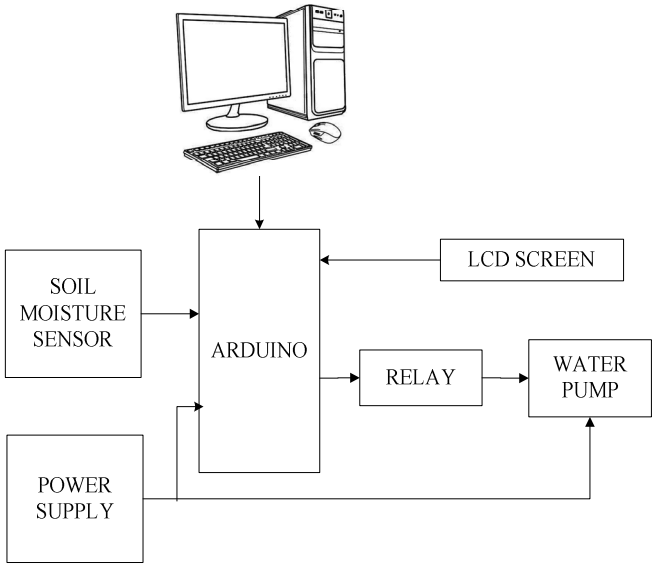

Fig. 9. Block diagram of Automated Irrigation System

IV. EXPECTED RESULTS

The uneven distribution of water table around the globe and increasing food demand due to decreasing cultivable land & increasing population, has encouraged work towards smart irrigation system to optimize net crop yield. Different irrigation techniques being practiced globally, has been discussed. In this regard smart irrigation technique based on Atmega328P Arduino microcontroller has been used to automate irrigation system. Operation of motor depends on soil moisture level content and atmospheric temperature. Motor operates to maintain soil moisture content within minimum and maximum moisture threshold value. This can optimize overall crop yield by providing adequate water to the considered crop. Such system saves energy and water requirement in areas having irrigation water shortage

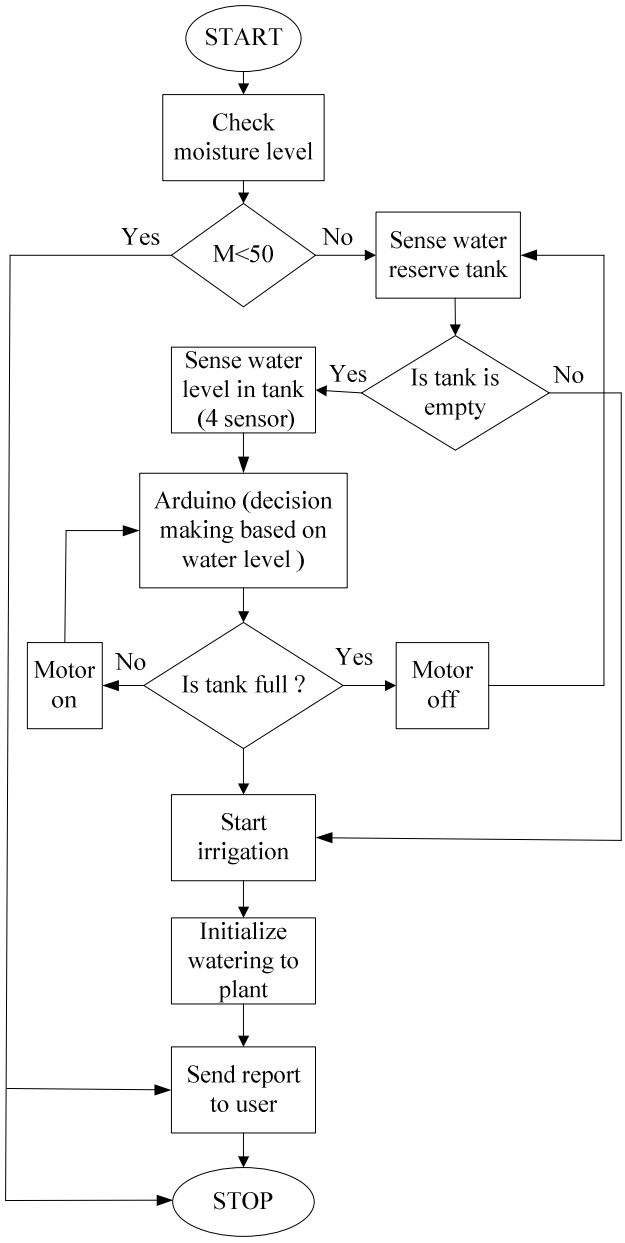

Fig. 10. Flowchart of Crop Automated watering system

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