INTELLIGENT SYSTEM FOR IRRIGATION BASED ON WATER FLOW CONTROLLING DESIGN IN DIFFERENT VEGETATION

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ABSTRACT:

India is an agricultural country where various types of crops are grown for different seasons with respect to the climatic conditions. As we know that each crop has separate irrigation process which is necessary to improve the productivity and quality of agro based products. Production of every crop in the field depends on the water level in the soil which is essential element for life sustenance of the plant growth. Hence we have designed an automated irrigation system which can be implemented for several crops on any terrain. This automated system will reduce the human aid and negate the wastage of flow of water in the field. This design has a microcontroller with a keypad display, the only work of the farmer is to specify what type of crop and area occupied for the cultivation. The microcontroller will process the data specified and calculate the amount of water required for that specific crop in that area , which will ensure a measurable amount of water will be spent on cultivation purpose. This design also automatically sense the moisture content of the crop and pump the water measurably. It can help more in the drought region where the wastage of the water can be reduced. The device is placed at an affordable price for the farmers. This is a low budget system with an essential social application.

1. INTRODUCTION

Now a day's conservation of the water has become a tedious process. Agriculture is the one of the field were water requirement is more than in any other occupation. Investments in water for agriculture has made a positive contribution to the rural livelihoods, food security and poverty reduction during the second half of the 20th Century food production has outpaced population growth all over the world, with some 78% of the production growth over the period 1961–1999 deriving From yield increases as opposed to agricultural land expansion. There has been an increase in irrigated areas and enhancements in water management on irrigated lands which has caused occurrence of high yields.

The area equipped with irrigation expanded from 139 million ha in 1961 to 277 million ha in 2003.Food prices – in absolute and real terms – have fallen over the past two decades, though recently prices have increased sharply, due to the need of agricultural products in non-eatable uses[1]. During the last 50 years, productivity gains have generated higher yields and incomes for food producers, while the consumers have been benefited through the lower food prices. Throughout those years and the recent outcomes, the irrigation development helped alleviate poverty by creating employment opportunities, lowering food prices, and increasing the stability of farm output Investments in irrigation have been increased rural incomes, resulting in the greater demands for nonfarm goods and services. As per the perspective the investment of water in the agriculture has been increased and will play a greater vital role in the production of the food system.

As in India the total economy is also a part of the agriculture in the country. Here for the crop production irrigation plays a vital role irrespective of the climatic conditions. For agriculture purpose we need lots of water for cultivation, sometimes most of the water are wasted due to unavoidable and unknown conditions. In this fast innovative world human beings require everything have to be automated. Our life style demands everything to be a remote controlled. Apart from these few things man has made his life automated. In the world of advance in electronics, life of human beings to be simpler. Hence to make life simpler and convenient way, we have designed an automated irrigation system based on crops and different vegetation. A deign for controlling irrigation facilities to aid millions of people. This model uses sensing arrangement technology with microcontroller to make a smart switching device. This device is designed based for the countries like India where the water has been wasted in the long manner for the cultivations of the crops due to the excessive supply.This model will brings the whole environment into a smart electronic control[2].

Agriculture uses most of the fresh water resources in the world. This tends to increase as the population of the world tends to increases. Water is a very precious natural resource that must not to be wasted. If too much amount of water is applied the problems arise consisting of runoff, erosion, wasting of water and deceased of plant life. If too little water is applied different problems will be arising such as a turf burnout. The key irrigation is striking to correct balance amount for optimal plant life with optimal use of the water[3]. This proposed system will reduce the labor cost as well as the wastage of the water by using a scheduling system with sub irrigation system which will reduce the leaching losses of the crops. As this method depends on the

- area occupied for the cultivation,
- minimum number of crops is used for the cultivation
- What type of crop is used?

From the above data, the balanced amount of water can be calculated which is mention and shown below.

1.1. IRRIGATION PROCEDURE

The irrigation process is based on two types which is the closed loop and the open loop controller. This proposed model is based on the combination of the above controllers. Here, the irrigation system works on different categories such as the predetermined parameters and setting the time limit. Some of these parameters are fixed for the session and are dependent on the agricultural features such as the kind of plants, kind of soil, leaf coverage, stage of growth, etc[4]. and some of them can vary and can be measured during the irrigation process such as this proposal has a microcontroller which can process the data specified by the farmer and generate a output value that will specify the amount of water needed for the cultivation of the crops.

The parameter which determines the irrigation of the crops is[5]: (Shown in Fig 1)

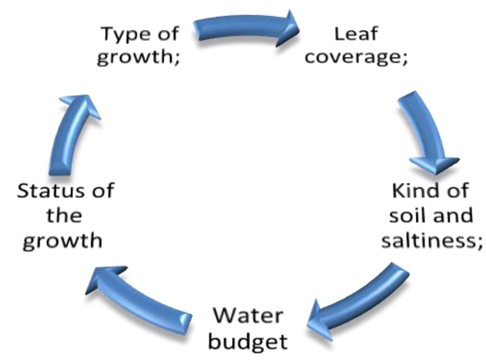


Fig. 1 parameters

1.2. FACTORS THAT DEPEND ON PLANT GROWTH

Water is not the only element for the growth of the plants, as it also depends on various other factors such as humidity and temperature of the region, soil moisture, wind speed, temperature of the soil and the atmospheric pressure. Sometimes evaporation and the evapotranspiration also affects the rate of the growth of the crop, which is unavoidable. So to find the requirement of the water in the crops, the above categorized factors have to be calculated based on unique circumstances which is shown below[6].

1.3. WATER REQUIREMENT OF THE CROP

The evapotranspiration rate is the amount of water that is lost to the atmosphere through the leaves of the plant, as well as the soil surface. Evapotranspiration is nothing but the difference in the actual water irrigated to that of the remaining water in the soil [7].

Calculation only for the one single crop:

- Let the area of the cultivation land be: Ac
- Minimum number of crops grown in the field: Nn
- The net average amount of requirement in irrigation: Ni (l/s/ha)

The standard value of this Ni is 1 litre per second for per hectare. This can be understood by the daily water requirement of 8.6 mm for cultivation .When the daily water requirement is 4.3 mm, the irrigation need would be 0.5 l/s.

Ni can be calculated based on different monsoon conditions, which are already derived based on the standard criteria.

S.No.	Soil temperature(average)	Monsoon seasons	N_i
1.	32 °F	Humid tropical climate	0.51/s/ha
2.	60–74 °F	Monsoon climate wet season	0.51/s/ha
3.	90–104 °F	Monsoon climate dry season	1.01/s/ha
4.	50–59 °F	Semi- arid climate wet season	1.01/s/ha
5.	100–104 °F	Semi- arid climate dry season	1.5 l/s/ha
6.	77 °F	Arid climate	1.5 l/s/ha

The net average irrigation = A_c * N_i ---(1)

The total water requirement for a single crop (S_c) =M x (average irrigation)

M= 100/E;

Where E is the efficiency of the irrigation, which depends on the crop pattern for various vegetation.

Water requirement for the overall crop in the cultivable area is given by

$W_R = S_c * N_n$(mm/day)

The above equation shows very less efficient output because there is so much loss that has to be considered during irrigation process. Some of the losses are stated below such as,

- Climatic loss
- Due Evapotranspiration loss
- Leaching loss
- Lateral percolation losses
- Conveyance loss

The above formula has to be modified based on with the above losses to prevent the wastage of water during the irrigation process[8]. The above net irrigation equation should be withhold with the temperature of the region , humidity, soil temperature, atmospheric pressure, wind speed, moisture content of the soil.

1.4. SINGLE CROP COEFFICIENT (KC)

As the evapotranspiration of a crop is directly proportional to the water requirement of the crop, which we seen above. As the some of the losses are emerged during this process to eliminate this, a crop coefficient or the crop factor is introduced which will combine with the evapotranspiration to give a output which comprises of all the losses in the irrigation process.

E_t is the evapotranspiration of the crop specified. (mm/day)
K_c is the crop factor
W_r is the total amount of water required for the crop. (mm/day)

$W_r = K_c * E_t$

K_c can be calculated based the temperature of the crops as well as the temperature of the cultivated region of the crops, which is shown below

T_{mx} is the maximum temperature of the region.
T_{mn} is the minimum average temperature of the region.
T_{sl} is the temperature of the soil
K_c is nothing but the growing degree rates.

$K_c = gdd = [(T_{mx} – T_{mn}) ÷ 2] – T_{sl}$

[9]Determining the evapotranspiration of a crop will definitely enhance the irrigation system water reduction, the evapotranspiration of a crop is nothing but the water which is evaporated in air due to the internal heat of the soil. This evapotranspiration factor can determined based on two methods such as

The Blaney-Criddle Equation and the Penman-Monteith Equation. This Two Equations are in Two Different Forms. We Use The Blaney-Criddle Equation which is very easy and the output can be accurate as it is easily fed to the microcontroller for the processing purpose.

E_T = Reference crop evapotranspiration (mm/day)

T_m = mean daily temperature (°C)

p = mean daily percentage of annual daytime hours.

$E_T = p (0.46 T_m + 8)$

T_m means temperature of the region, which is calculated based on

$$T_m = (T_{mx} + T_{mn})/ 2$$

1.5. IRRIGATION SCHEDULING

It is the process of scheduling the irrigation system based on the correct duration and the frequency of watering of crops. This proposed system will reduce water consumption by setting the correct duration for every single crop that is specified. The duration of all the crops will be stored in the microcontroller. Based on the crop the farmer specifies, the crop duration is automatically allocated[10]. The irrigation scheduling depends on

- Type of soil
- Soil temperature
- Development of the crops

From the various factors discussed above the crop growth need enormous amount of water, the growth of the crop is differentiated into various types such as

- Initial
- Crop growth
- Mid-season
- Late season

For the initial growth of any crop only less amount of water is required, but in the development period more amount of water is required for the growth, same for mid-season. During the harvesting time only less amount of water is consumed by the crops. To reduce the water consumption, the irrigation process is not done continuously, instead some intervals are given to the pumping system, for areas of drought and water shortage. This method is very useful to reduce the water consumption in the drought regions. The above statistic is not applicable for all the crops, but most of the crops growth is based on the above condition.
All the statistically data's along with the irrigation scheduling is stored in the microcontroller , as it gets activated based on the specification given by the farmer.

2. PROPOSED METHODOLOGY

The proposed architecture has three units for various execution purposes[11]. (Shown In Fig 2)

- *Input unit*

  It comprises with the sensor such as moisture, rainfall, soil temperature and the humidity sensor

- *Execution unit*

  Input from sensors is interfaced with microcontroller for performing various operations and execution.
- *Display unit:*

  It has a LCD screen with a keypad to specify the specifications of the crop with the cultivation area and to also know the status of the process.
- *Water unit:*

  It has a water pumping system with a thermistor and a cooling fan to avoid over heating of the system.

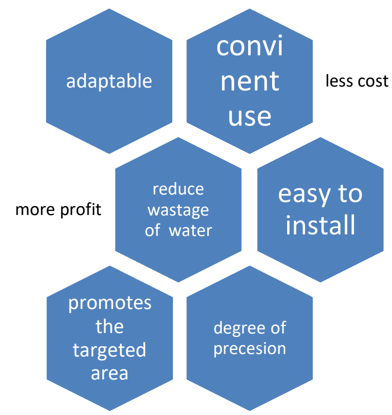
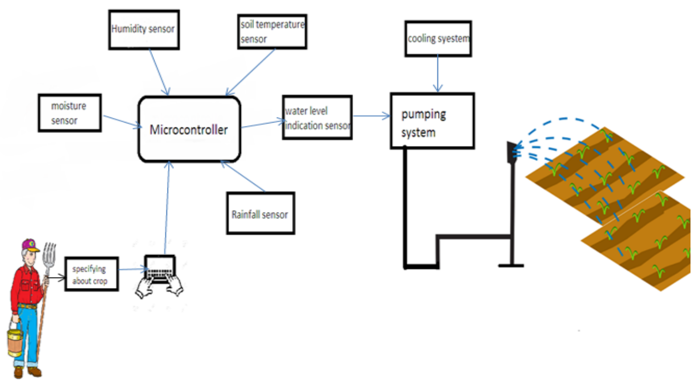


Fig .2 Necessity of this technology
Fig .3 System Architecture

In Fig .3 shows the automatic irrigation system based on vegetation, will minimize Man power requirement. This proposed system is done with the help of sensors with high accuracy, which makes the irrigation system a unique type of a product. This could reduce the manpower requirements which is the major fact for the holding back of farmers. This product will help a single farmer who can manage more than one field work. This design consists of a five highly accurate sensor with a pumping system, these systems are interconnected to a microcontroller. The farmer has to specify what type of crop is used for the cultivation purpose. The specified crop database is activated in the Arduino, and the temperature, humidity, moisture of the soil and the



soil temperature are fed to the Arduino as input data[12]. Then the area of cultivation has to be specified with the minimum average number of crops planted in the region to measure the exact amount of water required for the cultivation of the crop.

From the gathered inputs, the microcontroller calculates the amount of water required and the duration required for the irrigation process. The output is sent to the water level indication and the pumping system .The calculated amount from the microcontroller is further fed to these sensors to send the accurate amount of water required for the irrigation process. Due to recent water scarcity problems, this system would propose an efficient approach[13].

2.1. ARDUINO UNO

It is a microcontroller device which is used for performing operation and the execution of the task related to it. It has 14 digital pins and 6 analog pins with 16 MHz crystal for oscillation. It is assigned for the specific operation and the specific purpose only. The program is fed to the Arduino using a Arduino software which is done and interfaced with the system. The Arduino environment which receives various inputs from the sensors and other controllers and performs the task related to it. It is encoded with the help of Arduino programming language and with the development environment using the processing.

Here the Arduino Uno act as a execution unit, which does all the operation based on the program which we feed to it. The speed of the pumping motor and the amount of water fed are controlled using the arduino based on the input given by the sensor. As the data's about all the crops are been stored, based on the specification given by the farmer, the microcontroller acts on to it.

2.2. MOISTURE SENSOR

Moisture sensor also called as the soil moisture sensor, which measure the water content in the soil. Since the direct measurement of the free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature. These inputs are fed to the microcontroller directly, especially for crops that need to be in wet condition these sensors are used.

2.3. RAINFALL SENSOR

Rain sensors for irrigation systems are most employing hygroscopic disks that swell in the presence of rain and shrink back down again when they dry out, an electrical switch which is in turn depressed or released by the hygroscopic disk stack, and also the rate of drying is typically adjusted by controlling of the ventilation on reaching the stack. However, some electrical type sensors are also marketed that use tipping bucket or conductance type probes to measure rainfall. It is connected to the analog pin of the microcontroller, which states the amount of rainfall accurately. From this proposed model, when the rain fall is heavier the water supply to the crops won't be stopped instead it will be reduced to 60% of the overall flow. If the rain fall is lighter, the water flow will be reduced to 30% of the overall flow. Similarly the microcontroller automatically executes based on the data from the sensor.

2.4. HUMIDITY AND TEMPERATURE SENSOR

Humidity is the presence of water in the air. The amount of water vapor in the air can also affect cultivation process. The presence of water vapor also influences various physical, chemical, and biological processes. Hence, Humidity sensing is very important. In the agriculture sector, the crop growth also depends on the humidity and the temperature of it. The water used for the irrigation is also been controlled based on the humidity and the temperature of the crops. Controlling or monitoring humidity is of paramount importance in many industrial & domestic applications. Humidity control is also necessary for chemical gas purification, dryers, ovens, film desiccation, paper and textile production, and food processing. In agriculture, measurement of humidity is important for plantation protection soil moisture monitoring, etc. the temperature sensor will define the temperature of the region which is used in the blaney-criddle equation and the penman-monteith equation for the calculation of the water requirement of the crops in that region.

2.5. SENSOR SOIL TEMPERATURE SENSOR

SOIL MOISTURE AND TEMPERATURE plays a vitally important role for plant and crop growth. Different seeds require different soil temperatures to germinate and the soil moisture which is used to schedule irrigation and also even help predict crop yields.

2.6. WATER LEVEL INDICATION SENSOR

This sensor is immersed in the water storage tank to see the level of water in it and the microcontroller executes it based on the water level data, the amount of water send is also measured using this indicator.

2.7. IMPACT ON USING WIRELESS OVER THE CROP PRODUCTION

Using of wireless in this proposed model will have a unique advantage for the farmer, but the emf waves generated have a vigorous attack on the roots of the crop. As from the recent research, the emf waves affect the respiration of the crops. Likewise, the roots and shoots lengths of the crop also showed a significant reduction in the seedlings which is emerging from wireless modules which are exposed to the seeds. The inhibitory effects of the electromagnetic radiation (emf) were very much greater on root growth than on shoot growth.We have neglected wireless only to enhance the production of the crops more. As the respiration of the crops is affected, more amount of water is wasted due to it. The main objective is to save water in the agriculture field.

3. EXPERIMENT RESULT AND DISCUSSION

Experiment 1:

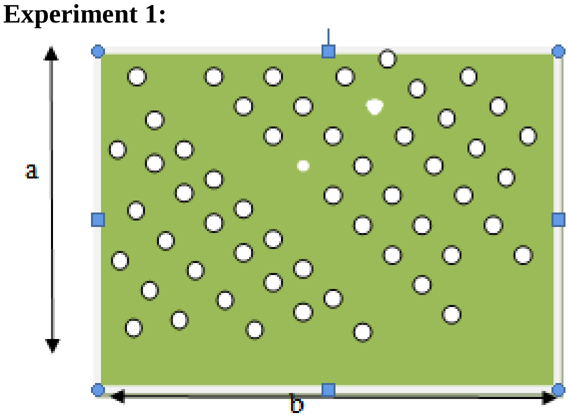


Fig 4 Cultivation area with 40’C

a	b	area	temperature	Wind speed	Type of crop	monsoon
50ft	20ft	1000sqft	40'c	50 knots	wheat	humid

From the above table for 1000sqft the minimum 550 crops can be planted, from this experiment the minimum number of water required is 1238 liters for the whole region for the cultivation, 4.8 liters of water is minimum required for the single crop for the over all duration before harvesting during a humid season.

Experiment2:

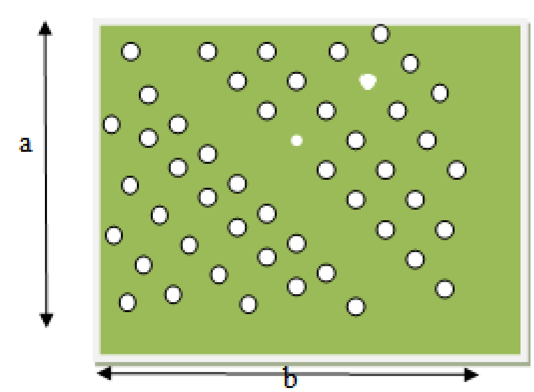


Fig 5 Cultivation area with 48’C

a	b	area	temperature	Wind speed	Type of crop	monsoon
50ft	20ft	1000sqft	48'c	33 knots	wheat	Dry climate

From the above table for this experiment the minimum number of water required is 1970 liters approximately 2000 liters for the whole region for the cultivation, 6.2 liters of water is minimum required for the single crop for the overall duration before harvesting during this dry climate season. As the soil temperature increases during this season , as for as the wind speed is concern to be very less.

Experiment 3:

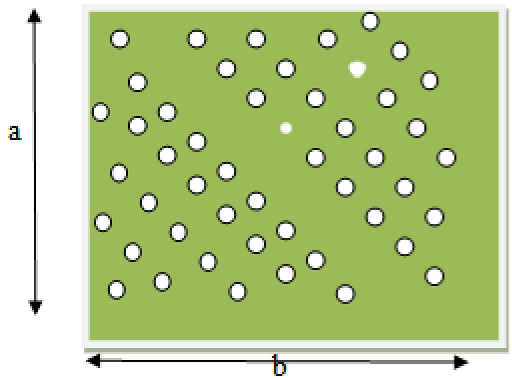


Fig 6 Cultivation area with 30'C

a	b	area	temperature	Wind speed	Type of crop	monsoon
50ft	20ft	1000sqft	30'c	36 knots	wheat	Tropical season

From the above table for this experiment the minimum amount of water required is 1123 liters for the whole region for the cultivation, 3.4 liters of water is minimum required for the single crop, for the overall duration before harvesting during a tropical season.

Experiment 4:

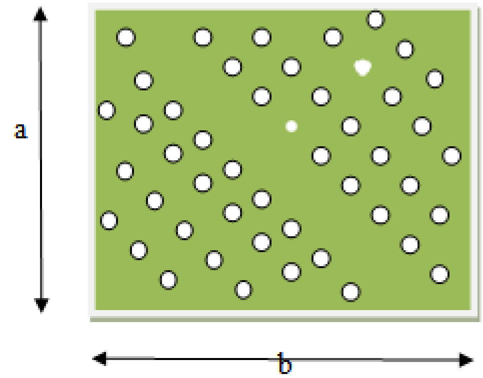


Fig 7 Cultivation area with 25'C

a	b	area	temperature	Wind speed	Type of crop	climate
50ft	20ft	1000sqft	25'c	44 knots	wheat	Semi arid season

From the above table for this experiment the minimum number of water required is 1460 liters for the whole region for the cultivation, 4 liters of water is minimum required for the single crop for the overall duration before harvesting during a semi arid season.

Table 1: overall experiment outcome for two different crops

Area(sq ft)	Type of crop	climate	Wind speed	Humidity of the region	Temperature of the area	Water irrigated(approx.)
1000	wheat	tropical	34 knots	wet	28'c	1200 liter
1000	wheat	Dry climate	45Knots	warm	56'c	1400 liter
1000	chilies	tropical	44Knots	wet	32'c	1050 liter
2000	chilies	monsoon	30Knots	Cold air	20'c	1000 liter
2000	wheat	Semi arid	50Knots	warm	48'c	1345 liter
2000	wheat	monsoon	45Knots	wet	23'c	1450 liter

The above table gives the experimental outcomes of two different crops such as chilies and wheat with respect to various other criteria such as various temperatures with different wind speed.

4. CONCLUSION

This automated system is to be a more effective one because it is user-friendly and it is found be more productive in nature. As the crop database has been completely stored in the system with the schedule. This system can further be modified with the solar cell in the main execution power unit, hence it can be brought out with more eco-friendly purpose. As in most of the rural areas power supply is not adequate, such areas will have an improvement with this tech.

This irrigation system will automatically change the irrigation pattern based on the crop specified. The scheduling process will work based on each different crop in the vegetation. This system will work not only on a single vegetation but also on multiple ones. The calculated amount of water is been fed more or less which will reduce the wastage of the water. This model is very easy to be controlled and can be operated with less manpower. Hence the system is so compatible which will change according to different vegetation , climate and environment.

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