Jol-Shinchon: Design and Development of a Sensor Based Intelligent Auto Irrigation System

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***Abstract*—Agriculture is the mainstay for Bangladesh and the provision of water is an important factor that determines the output of the agriculture sector. Since natural water availability is prone to many aspects of nature such as rain and capacity of rain-water reservoir, irrigation or alternative supply of water becomes a critical element in agriculture. The existing irrigation mechanisms through the motor-pumps are heavily dependent on fossil fuel regarded as an offender in the carbon footprint debacle. The poor farmers find themselves with insurmountable hurdles as they are constrained by the financial cost on fuel. The profit maximization gets a major setback due to the exorbitant amount of expenditure due to fuel consumption. An innovative approach to do away with such limitation is the utilization of natural resource for irrigation purpose, an intelligent auto irrigation system which is based on the concept of harnessing the power of sun. Through the use of solar panel, sunlight is captured into the photovoltaic cells and transferred to a battery to be charged during the day. All this setting is facilitated by circuits one associated with the solar panel and the other one for detecting the presence of sunlight during the day since the system would not allow any water to flow unless it is the night time. In order to drive the pump into action, two conditions need to be fulfilled one darkness, detected by a photo resistor and the second one is the dryness of soil, to be determined by a moisture sensor, and this setting would be programmed by a platform both hardware and software with Arduino Uno. Although the charging time of the battery by solar panel would be a little lengthy, the long exposure to the sun would provide enough time and charging volume to the battery. The battery would comfortably provide a considerable duration of power to the water pump that can supply sufficient amount of water to agricultural land of any decent size.**

***Index Terms*—Agriculture; Irrigation; Intelligent system; Solar Energy; Green Computing.**

I. Introduction

Irrigation is a process of supplying water from sources other than rain or any such natural phenomenon for arid agricultural land where places like dams, barrages, channels, or other devices are utilized. Irrigation has been in practice for as long as ten thousand years, predominantly in areas where annual rainfall is not more than 500 mm, typically in number of countries in Africa, Asia and America [1]. It is inevitable for places with wet characteristics, with specific crops, like rice. Estimation of total area under irrigation around the globe ranges in the figure of 543 to 618 million acres with approximately 50% of them in India, Bangladesh, Pakistan, and China [1].

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Bangladesh, being located in southern Asia, in the northeast of the Indian subcontinent, covering a total area of $144,000$ square kilometers, is known to the global community for various reasons. The country is mainly flat with some upper regions in the northeast and some in the southeast. A plain vast in proportion spreads from the southern part at sea level by rising in a gradual fashion up to the north [2]. Land elevation in the plain is of great variety ranging from 0 to 90 meters above sea level. The geo-morphological study of the country reveals that a bigger fraction of floodplains (79.1 percent) occupy the landscape, with a little allocation for terraces - 8.3 percent - and a tiny existence of hilly geography [3].

Climate of Bangladesh is characterized by a tropical monsoon setting which significantly varies in precipitation rate and temperature across the landscape. The seasons come in four appearances: pre-monsoon (March-May) possess the extreme heat and allocates the highest frequency of cyclonic storms, specifically in May; the monsoon spanning June-September - when the bigger chunk of precipitation occurs; the post-monsoon (October-November) is accompanied by tropical cyclones on the coastal region; and the relatively cooler and moderate level of sunshine (December-February). The mean annual temperature stands at about 25 degree C while humidity has a range between 60 - in the hot months - and 98 percent occurring in the rainy days [4]. Around 80 percent of the total rainfall takes place during the monsoon, and the average annual precipitation throughout the country is 2666 mm. rate of rainfall fluctuates - from $1110mm$ in the western region to 5690 mm in the northeastern districts [5]. Drought, floods and cyclones are regular occurrence of the climatic pattern for the country.

Despite the huge rush of water during the rainy season, stark discrepancy exists due to the lesser flow in the hotter period, surface water resources that can be utilized are regarded as equivalent to 80 percent of the reliable water-flow in March, leaving no alternative but to depend on surface water resources to be put into use comprehensively during dry seasonal extent for irrigation purpose [6].

Agriculture sector consumes a huge volume of water in Bangladesh. In the context of the thirst for water and failure to provide efficient irrigation mechanism, the time has come to go through a thorough understanding of the existing system for improving the irrigation approach and then build a robust system that would go a long way to mitigate the sufferings of the farmers who heavily rely on irrigation. So in this paper we propose an automation system consist of Arduino based power system and a solar panel associated circuit system to ease of the irrigation process.

Organization of the paper is as follows: a discussion on similar studies on the area is given in Section II, and the design and specific features of the proposed system are presented in Section III. Section IV contains an analysis of the implemented prototype and discussions. This paper concludes in Section VI following a section on the extension of this work.

II. Related Work

Sensor based intelligent auto irrigation system is mainly conceptualized in such a way that farmers can earn higher profit using the system. Apart from that, it is significant in ensuring that the system is scalable, efficient and reliable.

Watering is the most crucial practice in farming process. Watering system lowers the burden of providing water to plants when they require it [7]. Being aware of time and amount of water to supply are two important facets of water channeling process. There are different kinds of utilization of automatic water supplying system which are usually through sprinkler approach, tube, nozzles and other as such. This one is programmed in such a fashion that it will detect the moisture concentration of the plants and decide whether to provide water if needed. Such type of approach is utilized for using as a conventional plant care, as part of looking up for smaller and larger gardens. Usually, the plants necessitate watering two-times on a day to day basis during the sun rise and when it sets.

With regards to different shortcomings and setbacks, there has been a remarkable evolution in the approaches to go for irrigation with the aid of technology. The applied form of technology in the arenas of irrigation has turned out to be of enormous assistance as they offer efficient and accurate outcome. The authors in [7] have come up with a prototype, which transforms a plant into being more self-sufficient since it can water itself using a large water tank as a source and provides itself artificial sunlight by capitalizing the moisture sensors that need to be inserted into the soil - for getting an indication of level of moisture. The ultimate target of the system was to reduce it to a minimum the utilization of fossil fuel while keeping the utilization of solar power at maximum.

The authors in [8] discusses the rising need for energy, the ongoing diminishing impact of remaining availability of fossil fuels and the increasing worry regarding environmental degradation all of which have compelled people around the world to figure out new non-traditional energy resources that can be renewed where examples include solar energy, or using wind etc. in order to produce electrical energy. The authors put forward a solution mechanism for harnessing the available solar energy at maximum level as they can track the solar power. This implementation in Indian agriculture sector would result in a positive outcome. According to the paper [8], the irrigation system depending on the power from the sun would aid in reducing the void between the needed and the amount of energy under consumption. Furthermore, it helps to conserve the resources that would result in reduction of the spoiling of resource. This system accommodates the scope for improving through addition of temperature sensors and dissolving solid sensors into soil.

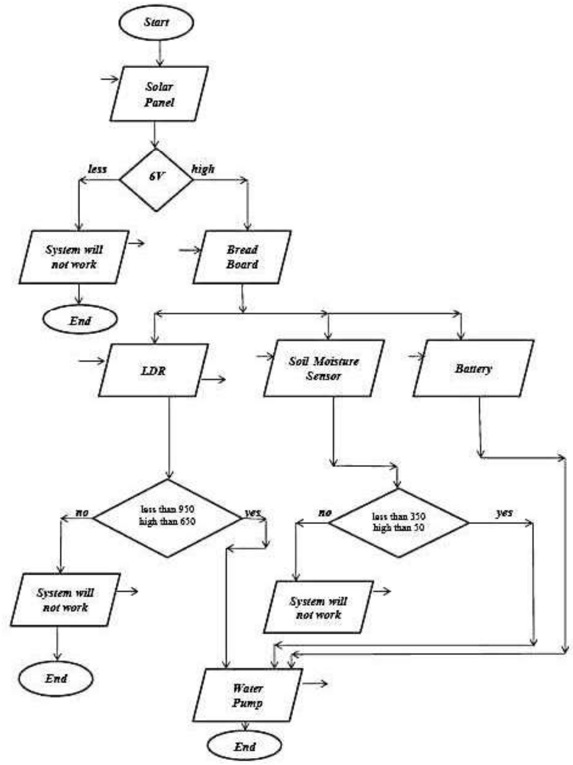

Fig. 1. Flow chart of the proposed system.

III. Proposed System

At present Bangladesh is trying within its limitation to break the barriers in agriculture especially in irrigation. However, the spiraling cost of fuel and uncertainty in availing electricity obstructs the irrigation required for producing crop in Bangladesh. So we developed a system that will be able to solve this issue.

A. Block Diagram

The system block diagram consists of many electrical components as shown in Fig. 1.

Firstly, we have used a solar panel which is going to charge the battery, and that battery will run the water pump. . The solar panel would operate at 17 volts. But the employed battery would run at only 6 volt. That is why a regulator needs to be used to control the voltage level. The solar panel that has been used to built the prototype has the following specification:

B. Components

Among the major components, we have the LM317 voltage regulator since it can be easily adjusted. Being an integrated circuit, the LM317T Voltage Regulator proves to be extremely handy in various energy applications that can be renewed. Its

TABLE I
SOLAR PANEL SPECIFICATION.

Operating Voltage (V_{mp})	$17.0V$
Operating Current (I_{mp})	$0.29A$
Open Circuit Voltage (V_{cc})	$21.6A$
Short Circuit Current (I_{sc})	$0.34A$
Maximum Power (P_{max})	$5W$

Fig. 2. Solar panel circuit.

usefulness is evident in regulating current, like regulating the current in an array of LEDs. Similarly, in order to provide a fixed voltage output with stability, this is also a good choice. LM317T would be employed in the circuit to achieve a non-standard, or in other words voltage that would be best suit.

Also we have the 1N4001 series or 1N4000 series belong to a genre of general-purpose silicon rectifier diodes which have gained popularity with 1.0 a (ampere) usually employed in AC adapters used in commonly found in appliances in domestic setting. Blocking voltage has variation in range of 50 and 1000 volts. This diode is constructed in an axial-lead DO-41 plastic package.1N4007 normal diode will be utilized with a view to a unidirectional current flow.

Next we have used the BC548 belongs to a general-purpose NPN bipolar junction transistor frequently employed in Europe in their electronic equipment. It is notable that many a time in the initial stage, the kind of bipolar transistor a hobbyist comes across is more than seldom found in designs exhibited in hobby electronics magazines which require a general-purpose transistor. The BC548 is less expensive and availability is wide. BC548 transistor switch would be the tool for calculating current level high or low.

In this system a variable resistor would be required to adjust the voltage originating from the solar panel. This resistor would be controlling the voltage and would turn the voltage to provide a value around 6.8V for supplying purpose. Since this is a variable resistor, the value cannot be set to a fixed one.

We have also used a Zener diode would allow current to be flowing from the anode end to the cathode terminal similar to a normal semiconductor diode, but it would also permit current to drift in the reversing direction when the Zener voltage is reached. Zener diodes are filled with a high concentration of p-n junction doping. Two types of zener diode are required in the system.

Two breadboards are required. In one board, the LDR and Moisture Sensor are connected, and with the other, the solar panel circuit would be built upon. In the bread board, there is a connection to the ground and V_{cc}, the (-) column is ground which is connected to arduino ground, and (+) is for Vcc there.

We are using a LDR here because of the sunlight. A LDR or light-dependent resistor is basically a light-controlled variable resistor. When the intensity of light increases, the resistance of the photo resistor starts going down. Thus it exhibits photoconductivity. An LDR is being used to determine whether there is light available or not. The LDR would be operational under the following conditions:

- At the presence of sunlight, the water pump will stop automatically.
- While it is dark, it will provide indication for the pump to begin the water to flow.
- A range of value would be set for Arduino for the detection of the presence of sunlight.
- Below 650 there is sunlight = water pump will remain stopped
- Above 650 the sunlight increases = water pump will start
- Above 950 there is no light = water pump will continue to operate

In our system a soil moisture sensor would provide measurement of the presence of the water level in soil. As the accurate level of gravimetric measurement of soil moisture necessitate the removal, drying up, and weighing of a sample, soil moisture sensors indicate measurement of the level of water through an indirect approach through the use of some other attributes of the soil. Such characteristics among others include dielectric constant, electrical resistance, and interaction with neutrons, for approximating the moisture content. The relationship between the attribute going through measurement and soil moisture need to be put under calibration and may cause difference relying on factors from environment, like soil nature, temperature, or electric conductivity. Soil moisture sensors determine the water amount in soil. A soil moisture probing device is built upon a number of soil moisture sensors. Technologies usually employed in soil moisture sensor constructions include:

- Capacitance sensor functions as a frequency domain sensor.
- Water neutrons are moderate by neutron moisture gauges.
- Electrical resistance of the particular soil.

We are using an Arduino Uno to control both LDR and Soil moisture sensor. In the prototype Arduino Uno is effective because it can control both resistor and sensor at a same time [15]. The Arduino Uno can be provided with power from the USB connection or an external power supply can serve the purpose. The board can carry operation by an external supply between 6 and 20 volts. When supply is below 7V, however, the 5V pin would be unable to provide a flow of a value more than five volts and the board would lose stability. The 5V pin would not be used for that reason. When the system would be flooded with a value over 12V, the voltage regulator may become a victim of overheating and find itself with damaging signs on the board. Hence, the recommendation is in between 7 and 12 volts. The Arduino Uno would be controlling the LDR

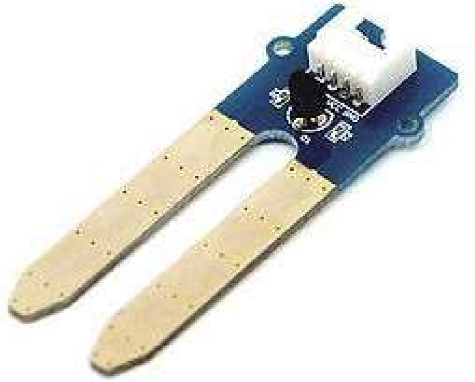

Fig. 3. Soil moisture sensor.

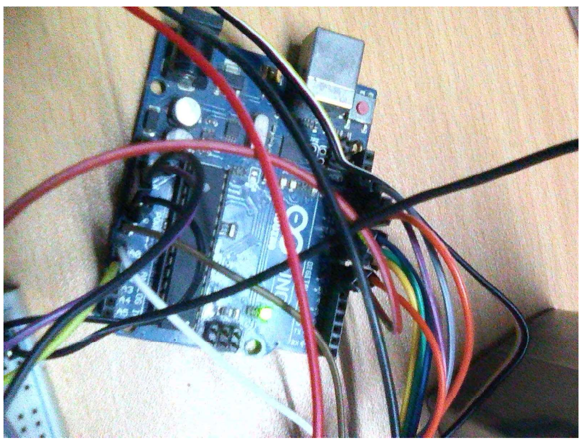

Fig. 4. Arduino Uno.

resistor and the soil moisture sensor at the same time in the setting, two pins A1 would be allocated for output from LDR and A2 output would be dedicated for Soil Moisture Sensor. The ground of LDR and Soil Moisture Sensor would have their connections to the power segment of Arduino. Arduino would provide a perfect 5V to the circuit, with the aid of relay to decide the LED lights to be allotted for output purpose.

There is a switch to control the water pump according to the range of LDR and Soil Moisture sensor which is known as relay. The relay is utilized for controlling two circuits via one signal. With the help of the relay, the battery gets connected and with that, the water pump in the system would be started. Relay becomes operational at 5 volts.

We have used different kinds of resistors in our system. Resistors are capable of performing two operations simultaneously. It could be put into use for reducing current flow, as well as could be utilized to reduce the voltage strength within a circuit. Several kinds of resistors would be put into use. In this regard, actually their purpose would be to ensure to maintain a value of 3.7V to LEDs.

We have used LEDs to show the output, so that a person can easily know the condition of the water level and as well as the sunlight. Six LED lights would be put into use for this scheme.

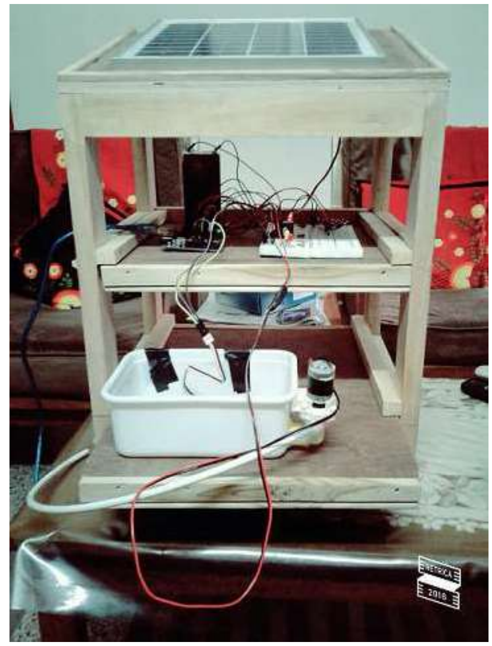

Fig. 5. Prototype of the concept.

Each LED light would be operational at 3.7 volt. Indication of light would be in the following setting given in Table. II:

TABLE II
LED LIGHT INDICATORS.

Light Color	Moisture Level	Sunlight Level
Red	Dry soil	No light
Yellow	Between dry and wet	increased sunlight
Green	Wet soil	Full sunlight

IV. RESULTS AND DISCUSSIONS

A photograph of the developed prototype is given Fig. 5. In our system there is a miniature water pump. The water pump would be used to artificially supply water from the ground for a particular task. It is subjected to electronic control by attaching it to a micro controlling device. It would get the trigger of ON/OFF via signals being sent from the battery.

A. Analysis for the prototype

The pump used in the prototype has the following parameters. The input voltage of the pump is 12 volt and input current of the pump is 0.25 amp, thus the input power of the pump is 3 watts. The water drawing capacity of the pump is 147.8 liter per hour. The formula which we have used to find the water pump flow is the following. The volume of water container we used in the prototype is 3.9 liter and the pump takes 95 seconds to empty the container. Thus the flow rate is 2.46 liter per minute, which is 147.8 liter per hour.

The size of the solar Panel used in the prototype is 12 inch by 8 inch, and it generates 5 watt at 17 volts, which is equivalent to 40 watt-hour energy when operated 8 hours in sunlight. The pump can be driven with the energy produced by the solar panel = 40 / 3 hours = 13.33 hours. The total water drawn from container: 147.8 X 13.33 liter = 1970 liter

B. Application of the system in the field

The following are the parameters of a pump suitable for use in the field. The input voltage is 32 volts and input current is 7.5 ampere, thus input power of the pump is 240 watts. With this configuration, the water drawing capacity of the pump is 10,800 liters per hour, and when when the pump is used for 10 hours, the total water drawn by the pump = 108, 000 liters. The electrical energy consumed by the pump is $240 \times 10 =$ 2400 watt-hour which comes from the battery [19].

On the other hand, the ratings of the solar panel can be used in the fields is 100 to 200 watts. If we use 3 solar panels for reference purpose, the total power produced by the panels is $3 \times 100 = 300$ watts, and these 3 solar panels produce 8×300 in 8 hours of sunlight = 2400 watt-hour [20]. With this configuration, a Boro rice field in Bangladesh requires 1 unit of this setup in 1 katha (720 square feet) of land area, and a wheat field requires 1 unit per 5 katha of land (3600 square feet) [21].

V. Future Work

The constraints encountered by the present system would be overcome by adopting a few specific plan of action. One key area requiring attention is the volumetric water control issue since performance of sprinkler and drip irrigation systems turns out to be heavily reliant on the qualitative aspect of design and materials chosen [6]. Moreover, restricting flow in delivery in surface irrigation systems originating from rotation, preset deliveries and discharges from unfamiliar sources are the main limiting factors in initiating exact field applications and irrigation arrangement in such systems [11]. How the field is evaluated for irrigation performance is a crucial means to enhance managerial issues as well as producing programmers for field assessment on-site is pertinent [12]. Lastly, it will be a revolutionary approach if the solar panel installed on the field can be made rotatory if it can move according to the direction of the sun on the sky.

VI. Conclusion

Bangladesh, being blessed with the rich fertile soil and the apparent lack of industrialization finds itself under obligation to put its best efforts for having a high yield in crop production. The uneven rain distribution throughout the year, coupled with the high demand of water for many crops during the dry season is a reality we have to deal with. The farmers even the better-off ones - find a larger share of their profits being eaten up by fossil fuel that power up the pumps for irrigation. Apart from the environmental pollution and health impacts, the economic strain caused by the huge amount of money spent on fossil fuel is a serious matter of concern. Although the charging time of the solar panel suggested by our system may seem a little lengthy in modern day standard, by employing larger solar panels and batteries with high wattage along with the powerful pump can ensure a huge yield in crop production under the setting. Apart from the pump, solar panel and battery, the rest of the components are not going to put any stress on even the poorest of farmers and again, the cost is just one-time investment.

References

[1] Modernization of irrigation schemes: past experiences and future options, FAO, 1996. p. 154-164.

[2] Journey plus (Geography). Retrieved from http://www.journeyplus.com/aboutbangladesh/geography-a-climate.html

[3] Bangladesh Bureau of Statistics. 1994. Yearbook of agricultural statistics of Bangladesh, p.273. Dhaka.

[4] Bangladesh Bureau of Statistics. 1995. Statistical pocketbook, p. 377. Dhaka.

[5] Bangladesh Bureau of Statistics. 1996. Statistical yearbook. Dhaka.

[6] Bangladesh Bureau of Statistics. 1997. Statistical bulletin Bangladesh, p.167. Dhaka.

[7] S. V. Devika, Sk.Khamuruddeen, Sk.Khamurunnisa, Jayanth Thota, Khalesha Shaik. Arduino Based Automatic Plant Watering System. International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 10, October 2014.

[8] Binoy Seal, Omkar Shirke, Siddhesh Shewale, Abhilash Sirsikar, Priya Hankare. Solar Based Automatic Irrigation System, International Journal of Research in Advent Technology, Vol.2, No.4, April 2014.

[9] A Iqbal. 1997. State of land, water and plant nutrition resources in Bangladesh, p.19.

[10] Ministry of Agriculture. 1996. Bangladesh food and agriculture: World Food Summit, p. 26. Rome.

[11] National Irrigation Development Project. 1994. Modernization of irrigation schemes in Bangladesh, p. 155-165. Dhaka.

[12] Sir William Halcrow & Partners Ltd. 1997. National minor irrigation census, Bangladesh 1995/96 irrigation season, p. 21. Government of Bangladesh, Ministry of Agriculture.

[13] Statistisches Bundesamt. 1992. Landerbericht Bangladesh, p. 117.

[14] Information and reporting system for water and agriculture in Asian monsoon, Food and Agriculture Organization of the United Nations.

[15] Design and Development of Precision Agriculture Information System for Bangladesh, Department of Computer Science & Engineering, University of Dhaka, Bangladesh.

[16] Solar power auto irrigation system using micro-controller, Retrieved from http://microcontrollerslab.com/.

[17] Arduino Soil Moisture Sensor. Retrieved from http://www.instructables.com/id/Soil-Moisture-Sensor/

[18] BD tech 12V 100AH IPS & Solar Battery Retrived from http://www.bdstall.com/listingDetail/index/8342/

[19] Mini 24V DC water pump. Retrieved from https://www.alibaba.com/product-detail/China-OEM-mini-24V-brushless-DC_60542105012.html

[20] Portable solar system 100 watt solar panel. Retrieved from https://www.alibaba.com/

[21] Irrigation Manual, 1992, Published by Department of Agricultural Extension, Ministry of Agriculture, The Government of Bangladesh.