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An Intelligent Automated Irrigation System for the Jordan Valley Area

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Abstract— Jordan is one of the most water-scarce countries in the world. The Jordan valley area produces more than 60% of the Kingdom's fruits and vegetables.

The Jordan valley area has dry and warm weather almost all around the year. These climatic conditions, coupled with low water holding capacity of the predominately-sandy soils in the Jordan valley area, make irrigation indispensable for the high quality landscapes desired by Farmers since it is the main agricultural area in Jordan.

The idea of this paper is to design an intelligent automated irrigation system for the Jordan valley area; which will ensure efficient water allocation and higher performance.

The automated irrigation system suggested is a PIC microcontroller based system that monitors air humidity, soil humidity, temperature, sun light, levels of water storage tank, and drip irrigation pipes for any cut or damage all the time, and display these parameters on an LCD screen as human interface, the user will be able to view the system status and to will be alerted for any damage, low water level or any water leakage at the drip irrigation pipes.

The suggested system is applicable and can be implemented to work for large areas like the Jordan valley area with a very low cost design and saves a lot in the terms of the water used for irrigation.

Keywords- irrigation; Jordan valley; drip irrigation; PIC; automated system; air humidity soil humidity; temperature; sun light; crops.

I. INTRODUCTION

Agricultural land in Jordan is limited to 8% of the total land area in Jordan; this land is heavily dependent on irrigation. The majority of Jordan's agricultural produce (over 60%) is grown in the Jordan Valley which is a part is part of the Great Rift Valley.

The Jordan Valley can be considered a natural green house with the relative advantage of producing off-season fruits and vegetables. Although its area represents less than 5% of Jordan's area and its population less than 6% of the country's population, the valley produces more than 60% of the Kingdom's fruits and vegetables [1].

The Variations in temperature, humidity, and rainfall in the Jordan valley produce distinct agro-climatic zones. There are also clear variations between the northern, central, and southern parts of the Jordan Valley in terms of water availability, water quality, and soil type.

The nature of the Jordan valley area combined with all the above variation results in that the land is heavily dependent on irrigation.

Water resources in the Jordan valley are very scarce and deteriorating, which severely constrains agricultural production.

The Jordan Valley irrigation scheme receives its water from the Yarmouk River, just upstream of the confluence with the Jordan River, at the northern end of the valley. Water is fed into a concrete canal that runs parallel to the river on the eastern bank.

Current governmental water management is not effective in encouraging water efficiency by agricultural users, and on-farm efficiency is estimated around 30 to 50 percent [2]. The annual available water resources in the valley are estimated to be 300 –350 million cubic meters (MCM), while the annual demand exceeds 500 MCM. The agricultural land that could be irrigated represents about 60% - 70% of the irrigable land in the valley due to the lack of water resources [1].

Water rights are also limited by quotas based on the type of crop grown, with more water-intensive crops such as bananas and citrus receiving a higher share. The government has prohibited the planting of any new areas with bananas or citrus, which limits water use but institutionalizes a market advantage for farmers entitled to grow these lucrative crops. These farmers have little incentive to switch to more water-efficient crops because to do so would forfeit their higher quotas [2].

In the Jordan Valley, farmers complain about the low pressure of the Jordan valley association operated irrigation system and regularly leave their valves open to collect additional water to properly irrigate their fields.

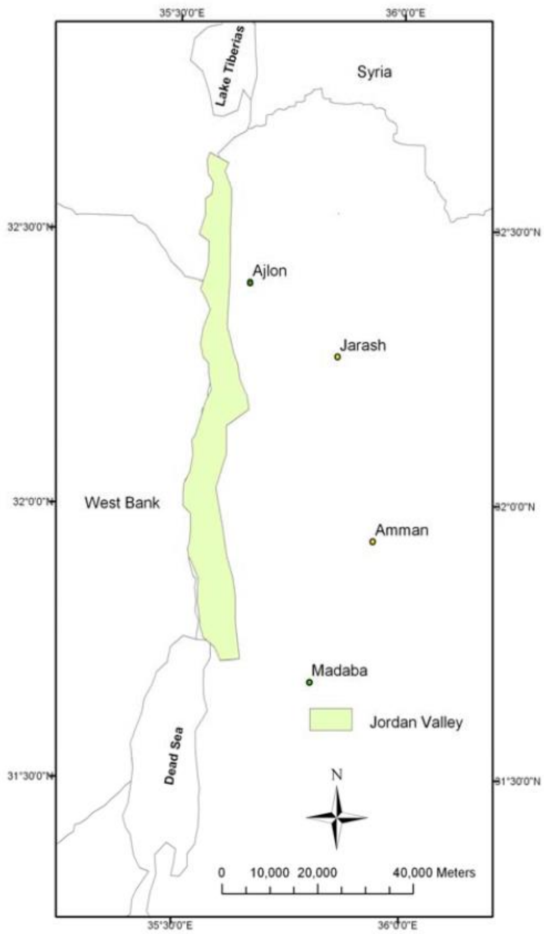

Figure 1: Location of the Jordan Valley in Jordan

II. Irrigation System in the Jordan Valley and Challenges Facing It

The main goal of irrigation is to supply the entire field uniformly with water, so that each plant has the amount of water it needs, neither too much nor too little, irrigation also has a few other uses in crop production, which include protecting plants against frost, suppressing weed growing in grain fields and helping in preventing soil consolidation

Irrigation is in a quiet crisis. Despite undeniable past successes in contributing to food production, irrigation expansion has dramatically lost momentum since the 1980s due to a considerable slowdown in new investment, losses of irrigated areas due to water logging, salinization, aquifer over-drafting and urban encroachment in some countries[4]. However, irrigated agriculture remains essential for future food security.

One of the factors that have contributed to the lack of interest is the poor performance of large-scale canal irrigation systems. These systems used in the Jordan valley area are the most difficult to manage and have yielded the lowest returns compared to their expected potential.

The Jordan valley association converted Jordan Valley irrigation distribution networks to pressurized pipe networks to improve irrigation water utilization efficiency in both the networks and on-farms. Farmers have to use the pressurized networks to enable them to install modern micro-irrigation systems. The original design of the Farm Turnout assembly included a flow-limiting device (flow limiter) to give a maximum flow of 6 litres per second [8].

This solution faced many objections from the farmers for many reasons. Some of these reasons were that the on-farm irrigation systems existing at the time could not be operated by small the small amount of flows and the crops, especially tree crops would suffer.

Another reason was that night irrigation was impossible in some areas, and small flows need long irrigation periods extending through the night.

The solution suggested by the Jordan valley association was to increase the water flow to 9.9-12 litre/second instead of the original 6 litre/second, which led to distribution of water to farms to a fixed rotation schedule once or twice a week [8].

Farmers could not get water except on their turn in the rotation, which means prevented water scheduling according to crop and soil requirements.

The main challenge in the Jordan valley area is that it has many variations between the northern, central, and southern parts of the Jordan Valley in terms of water availability, water quality, and soil type and also that different types of crops need different amounts of water.

III. A Proposed Model for an Automatic Irrigation System for the Jordan Valley Area

The idea of this paper is to design an intelligent automatic irrigation system to improve the efficiency of water utilization in the Jordan Valley Area.

The suggested system is a PIC microcontroller based system that will monitor air humidity, soil humidity, temperature, sun light, levels of water in the storage tank, and drip irrigation pipes for any damage all the time, and will display all of these parameters on an LCD screen as a human interface for the farmer to view the system status and to be alerted for any damage, low water level or any water leakage in the drip irrigation pipes , the system will turn on the water pumps automatically only during the night time which will minimize the water loss due to evaporation which happens during the daytime.

The system will automatically control and drive a water pump according to these parameters on a preconfigured irrigation sequence.

1. The system will decide whether it is day or night corresponding to the LDR (light dependent resistor) output.
2. The system will check the soil humidity level, and then in accordance to the humidity percentage the system will control and activate a water pump in order to start the drip irrigation process until the soil humidity percentage in the test area becomes in range of the desired humidity percentage for the specific plant.
3. The system will activate a buzzer alert and display a message on the LCD screen in case of overheat or drip irrigation water pipes damage in any of the pipes and locate the damage or loss zone.
4. As an extra feature for the system and to make it more reliable, a digital switch will be added to give the farmer a manual control over the system and activate the water pump.

A block diagram describing the proposed model is shown in Figure2 below.

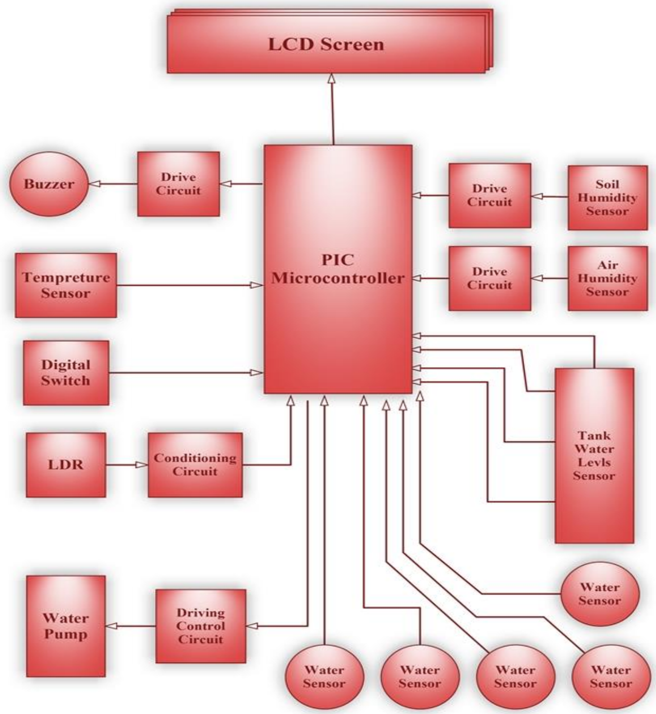

Figure 2: General Block Diagram of proposed model

IV. HARDWARE IMPLEMENTATION

The Hardware Components used are the PIC Microcontroller which we used for its many advantages some of them are low cost, wide availability, large user base, availability of low cost or free development tools, and serial programming re-programming capability [4], a character based LCD is used as an interface between the microcontroller and the user, a temperature sensor whose output voltage is linearly proportional to the Celsius (Centigrade) temperature, a Humidity and Resistive Humidity Sensor, A DC Motor, a Voltage Regulator to maintain a constant voltage level, and a Buzzer

Figure 3 shows the hardware implementation of the suggested automated irrigation system.

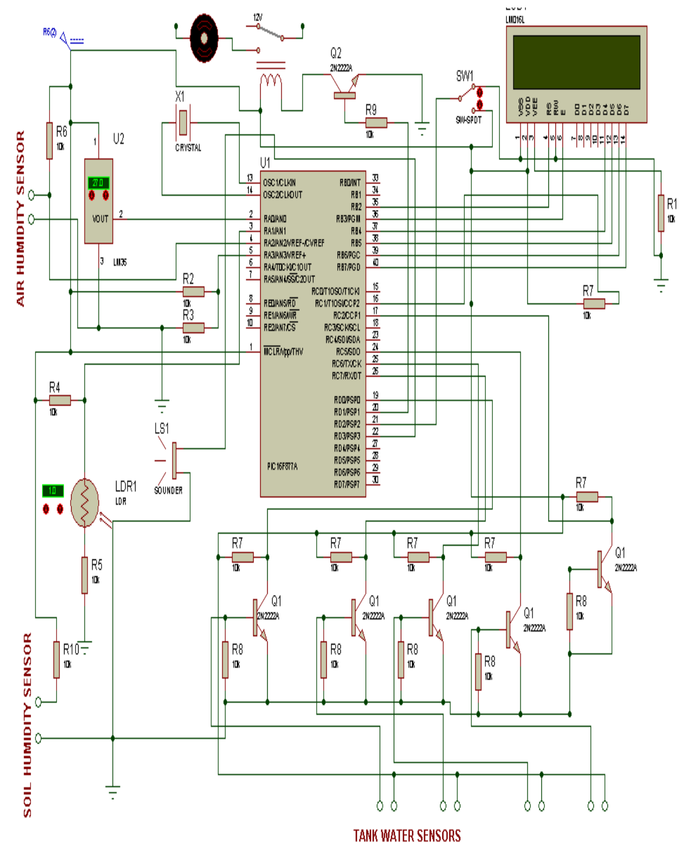

Figure3: Hardware Implementation

V. SOFTWARE IMPLEMENTATION

The language used for programming the PIC is Mikrobasic V7.0.0.2 [7]. MikroBasic allows to quickly develop and deploy complex applications like Writing BASIC source code using the built-in Code Editor, using the included MikroBasic libraries to speed up the development, data acquisition, memory, displays, conversions, and communications.

After writing the code and compiling, it is installed on the PIC, the IC-PROG universal serial program converts the source code we wrote to hexadecimal machine language, and then the program can be easily downloaded on the PIC using a small circuit called programmer which is connected to the computer by a parallel port.

Figure4 shows the flow chart used to write the program, which was downloaded, on the PIC using the programmer mentioned above.

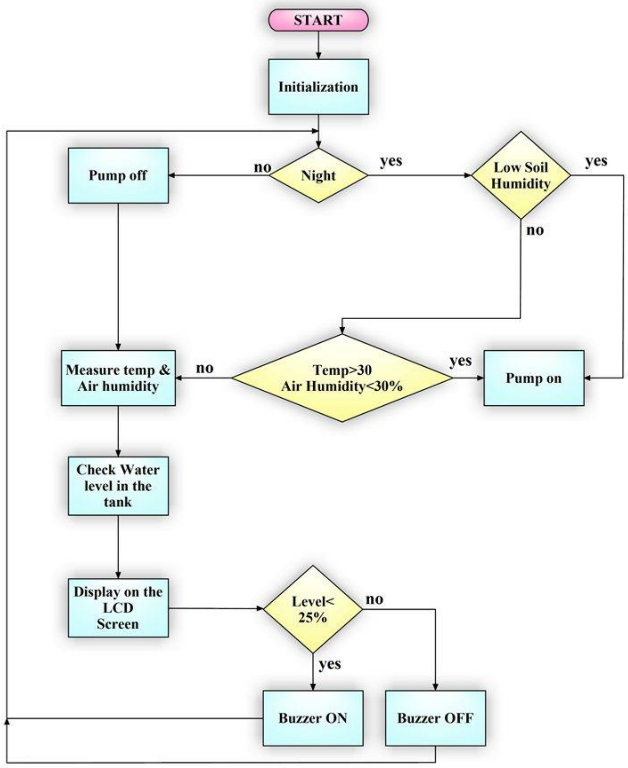

Figure4: Flow Chart of the software implementation

VI. SYSTEM OPERATION:

The proposed system's operation goes through many steps, first the system is initialized and then decides whether its day or night depending on the LDR output.

If it is daytime the system will turn the pump off and measure the temperature and the air humidity, the system will also check the water level in the tank and eventually display all the readings on the LCD screen, if the water level in the tank is below 25% a buzzer will alert the farmer. We note here that irrigation is not preferred during daytime due to high evaporation rates resulting in a high percentage of water loss.

On the other hand if the LDR readings indicate that its night time, then another cycle will take place, first the soil humidity is tested using the soil humidity sensor if the soil humidity is low that means that the plant requires irrigation and the pump is turned on.

If the soil humidity is not low other variations must be tested like the temperature and the air humidity percentage, if the temperature is above 30^{o}C which is a very high temperature accompanied with an air humidity percentage less than 30% which means a very dry weather, the very hot and dry weather requires irrigation , the system will automatically turn the pump on.

If the pump was not turned on, the system will measure the temperature and the air humidity, the system will also check the water level in the tank and eventually display all the readings of the various sensors on the LCD screen, if the water level in the tank is below 25% the farmer will be alerted by a buzzer.

We not from the system operation described above that the system will only turn on the pump automatically in predefined cases and under some conditions depending on many variables.

1. The system will turn on the pump only in nighttime in two case , the fist case if the soil humidity is less than 25%, and the second case is that the temperature is above 30 and the air humidity is less than 30% which means a very hot and dry weather .
2. In the case that the pump is turned off, readings of the temperature and the air humidity and the water level in the tank are taken and displayed on the LCD screen for the farmer, if the water level in the tank is below 25% a buzzer will alert the farmer.

VII. RESULTS

The system was connected and tested on a small area of land for different crops with different irrigation needs and proved to be very efficient after applying many variations on the test area.

The variations where in temperature, light, humidity of soil and air, and gave many satisfying results as the water flow from the drip irrigation pipes varied according to the above variables.

The system increased the efficiency off the water utilization since irrigation happens only in nighttime.

VIII. CONCLUSION

The main purpose of this paper is to build an efficient automated irrigation system, the main advantage of the work is that it attempts to make an applicable fully automated irrigation system that depends on many variables like temperature, light, humidity of soil and air all measured by sensors without any human intervention.

After verifying that the system works, using the detailed hardware and software implementation discussed above, the system can be implemented to work for large areas like the Jordan valley area, which has many different crops all with different irrigation demands with a very low cost design.

Many enhancements can be added to the system. The system can be made more accurate, for a little extra cost, since the system works properly in general, in order to increase the accuracy and the resolution of the system, more precise sensors can be added, we may also develop the PIC and replace it with motherboard, another improvement is to link the tank with a water source and add a switch to control water flow in to tank connected.

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