SSRG International Journal of Electrical and Electronics Engineering
ISSN: 2348-8379/ https://doi.org/10.14445/23488379/IJEEE-V10I3P106

Volume 10 Issue 3, 52-58, March 2023

Original Article

Technified Irrigation System for Crops using Automated Technology to Optimize Water Consumption in an Efficient Way

Joe Vicente Herrera[1], Victor Romero-Alva[2]

[1]*Faculty of Science and Engineering, Universidad de Ciencias y Humanidades, Lima, Peru*
[2]*Image Processing Research Laboratory (INTI-Lab), Universidad de Ciencias y Humanidades, Lima, Peru*

[2]*Corresponding Author : vromero@uch.edu.pe*

Received: 16 January 2023 Revised: 02 March 2023 Accepted: 14 March 2023 Published: 29 March 2023

Abstract *- Improving crop production is receiving much attention in recent years, but this does not mean that we should spend more water than necessary to keep them constantly hydrated or increase the consumption of fertiliser for higher production, although these practices are still performed to date, taking advantage of technology, and electronic automation can implement an automated system that can irrigate regularly and constantly, at times that are conducive and timely, applying sensors can monitor crops. The humidity sensor determines if the roots are lacking water, the temperature sensor determines the temperature of the soil, and the rain sensor gives us the conditions of aqueous precipitation; when these conditions are adequate and are not harmful, irrigation is executed immediately, in addition, a level sensor determines the existence of water in the reservoir at the start or during the process is exhausted, the system will issue a message on your screen, with a warning to supply the reservoir. This whole process is done automatically without human intervention. This process makes a substantial saving in water consumption, with an average of 3.8 litres per 1.65* m^2 *area approximately, due to the fact that the ducts are placed in the ground with drippers that take the water directly to the crop plant without it being wasted.*

Keywords *- Technified irrigation system, Process automation, Crop, Optimization of water consumption, Arduino, Irrigation control.*

1. Introduction

Water is an element that constitutes almost 70% of the planet's surface, but only 2.5% is fresh water. This is divided between glaciers, snow or ice, groundwater and rivers. Less than 1% of water is available for human consumption and the ecosystem. Of this percentage, 12% is used for the population, 19% for the industrial sector and 69% for the agricultural sector. It is a scarce element in various parts of the planet. UNESCO [1] mentions that the problem is not the decrease in drinking water but the increase in the population, there are territories where the population has grown excessively, and this leads to higher consumption; on the other hand, climate change is exerting meteorological changes in all countries, it is necessary to take measures to protect the environment because this would have repercussions that would affect everyone [2], [3].

For agriculture, water is an essential element, which is why it is one of the reasons why it must be used adequately and responsibly in order to be able to consume what is necessary without wasting it and to extend its use to greater distances of agricultural land if we do it with rudimentary techniques as it is being done, we will not be able to have sustainable agriculture. Hurtado's work [4] mentions that: water must be used and used properly where the plant needs it, and at the time it is required because it is not possible to exceed humidity or provide it in places where it is not adequate, so it is essential to know the conditions and the environment to act properly in the development of plants.

In many agricultural fields of the country, gravity irrigation distributed by canals is still used; this system is ambiguous and inefficient because a lot of water is wasted; using this technique washes the crop fields that have been previously fertilized or sprayed, which wastes fertilizer or pesticide, proving to be an inadequate technique to irrigate the crop fields, wasting money and time. However, despite its disadvantages, it is still used to date. In an article by Basso [5], knowledge and technologies already exist in many cases. However, the possibility of them reaching the producers must be increased, strengthening their capacities and encouraging their adoption to increase their competitiveness and add value to the process.

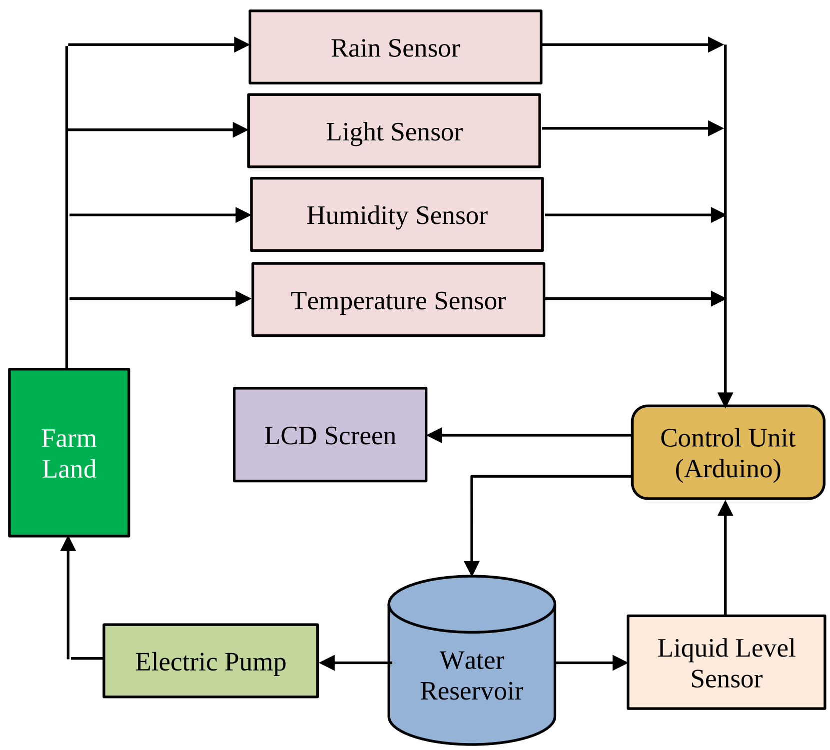

Fig. 1 Block diagram

Likewise, the world's population is increasing every year, and this leads to an increase in food production; however, it is true that the land under cultivation will not increase. However, it is possible to improve the quality and increase the production of agricultural crops with the help of technology. According to a United Nations study [6], The world population in 1987 was 5,000 million. In 1999 it was 6,000 million; in 2020, it was 7,700 million, and it is estimated that by 2050 and 2100, there will be 9,700 and 11,000 million inhabitants, respectively.

This idea of irrigation control using technology arises from an article written by Cuzco (Et.al) [7] mentions that: "if home automation is used for the benefit of people in the home", it can also help people in the field and in the same way, facilitate and allow not to be so dependent on them to perform additional or parallel tasks at the same time. He points to drip irrigation for its ability to reduce water consumption and the costs associated with irrigation, especially labor costs.

In this crop irrigation alternative, water is applied locally, only where the roots of the crop develop; as Arias mentions in his thesis [8] that: thus, drip irrigation can irrigate some crops with a lower amount of water than would be needed if other irrigation methods such as sprinkler irrigation are used. There are several options for setting up a fertigation system. The simplest are easy and inexpensive to implement, while automated systems can be expensive.

When working with large units and/or the potential value of the production is high, it is recommended to work with more sophisticated systems since they allow adequate management of fertilizers and other compounds such as acids and hypochlorite. In an article, Martinez [9] mentions that: the savings produced by adequate management of the fertigation system, whether the product or the labor, helps to cover the costs of a more complex system.

The objective of this article is to implement an Automatic Technified Irrigation System, which would generate savings in water consumption and the use of fertilizers. It would also reduce the hours of work used in irrigating crops, which would substantially help the farmer and generate a more efficient and sustainable production, achieving a quality harvest.

The technology to be used in collecting information from the reservoir's rain, humidity, temperature and water level sensor sensors, which will provide the existing weather conditions and crops. The control unit consists of an Arduino Nano board and would perform the programming generating an algorithm for the benefit of the crop; all this information would generate the decision-making automatically and would run the off and on of the electric pump for both the water supply and irrigation of crops. All this will be done without the need for the presence of the farmer; his intervention will only be of supervision and control.

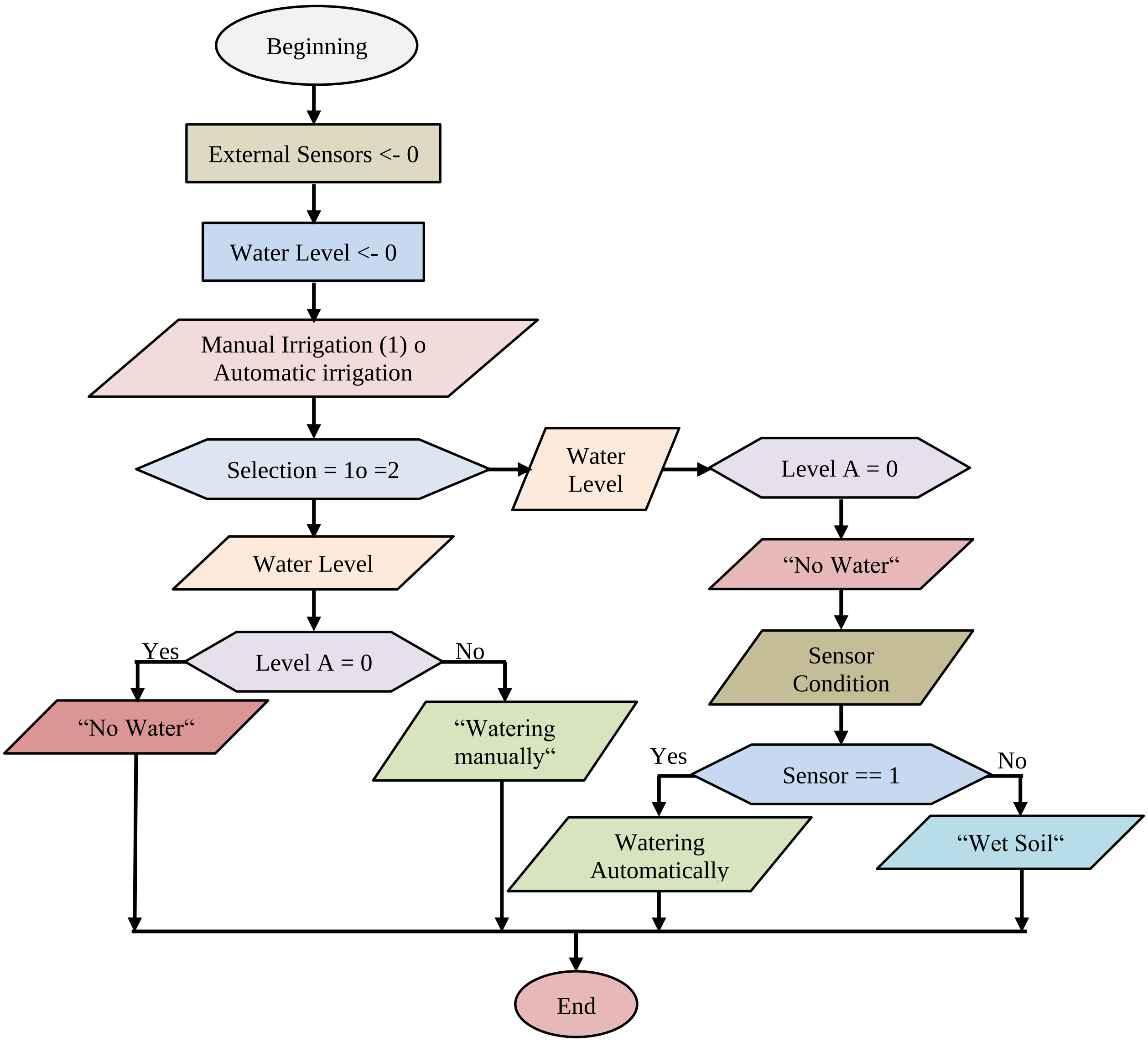

Fig. 2 Main flowchart

2. Materials and Methods

This work seeks to improve traditional agriculture to efficient and sustainable agriculture by developing an appropriate technology according to the needs. This process contemplates two stages, in which the implementation of the automatic technified irrigation system will be carried out.

The first part covers the acquisition and installation of devices [10], components and electronic sensors based on the Arduino; this constitutes the physical part. Moreover, the second part will be developed an algorithm that is able to make decisions automatically, without the need for the intervention of the farmer, only based on the information from the sensors that these will provide on the situation and condition in which the plants are.

We will start with the block design (Figure 1) of the automatic technified irrigation system, in which we will provide a general description of how it will be set up.

For the development of the implementation in the electronics part of the system, we will use components and sensors based on Arduino [11]. The choice is because it is a hardware platform and free software to contain a reprogrammable microcontroller, which also gives us a variety of devices that complement each other.

For the implementation will be used:

Arduino Nano R3 module where the LCD screen, sensors, water pump and power supply will be connected, in addition to collecting the information from the sensors and recording the programming to execute the irrigation.

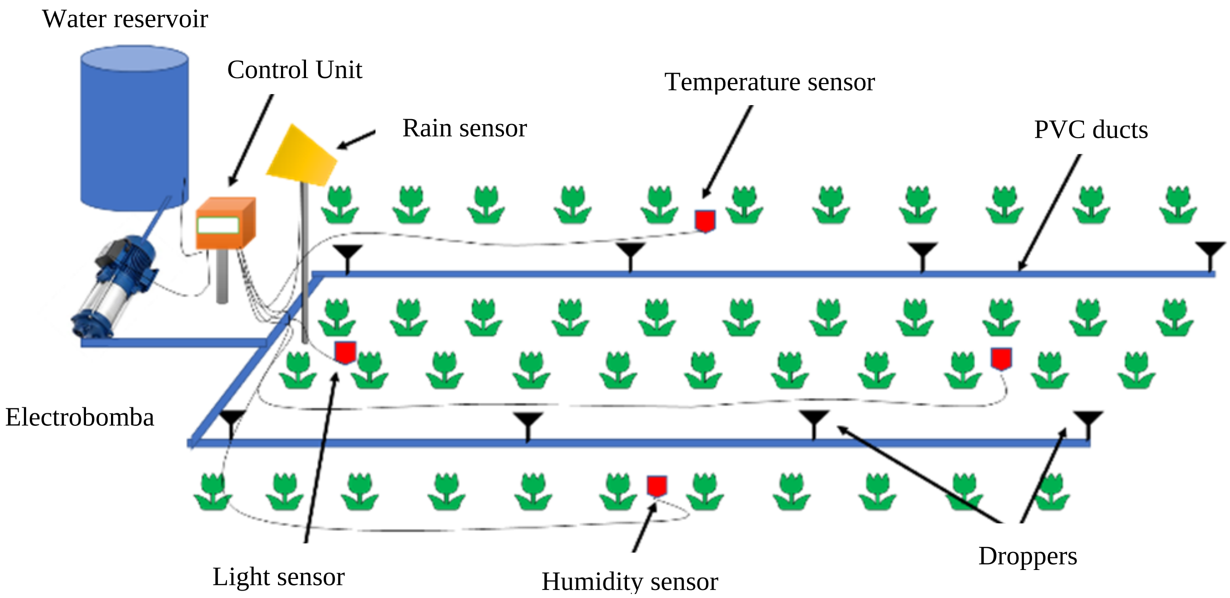

Fig. 3 Diagram of automatic technified irrigation system implementation

Shield Expander for Arduino Nano module that expands the logic connections and electrical current of the Arduino nano with which we can connect all devices.

5V voltage supply, this module will keep the Arduino Nano V3, LCD display and sensors running. Rain Sensor Module MH-RD this sensor determines the presence of rainfall in a given area and is a parameter with which to decide on irrigation.

Soil moisture sensor HL-69 is intended to measure the level of moisture in the soil, with which we can determine the root moisture.

Digital Temperature Sensor DS18B20 will allow us to know the existing temperature in the soil because a high temperature is not suitable for irrigation.

Illumination Sensor LDR 12 mm. Its objective is to determine the intensity of light in the zone. If this intensity is too high, it does not allow irrigation.

Liquid Level Sensor is a component that will indicate the existing water level in the reservoir tank. Relay module 4 channels 12V allow controlling the closing and opening of the water pump for irrigation.

Water Pump 12 V this pump generates the water flow from the reservoir tank [20] and directs it through the PVC pipes, reaching the farmland.

An LCD display device that will show the status of the control unit in the working process and the measurements of the different sensors.

Rotary encoder is this rotary component whose direction will give us options to choose a certain function.

On the other hand, we begin with planning the logical part of the system [13], starting with the flow chart (Figure 2), which will give us a vision of the system's structure to be implemented. The implementation of the automatic irrigation system would be embodied in a certain area arranged as shown in the conceptual representation (Figure 3) so that it starts to perform the irrigation work on the sowing sites.

3. Results and Discussion

In implementing the Arduino-based automatic technified irrigation system (Figure 4), it is intended that the system collects information from sensors located within the cultivation area so that the plants have the necessary humidity for their development and that there is no lack of water. The system has three options (Figure 5), one of which is "Manual", the other is "Automatic", and the third is "Turn off irrigation" this last option turns off the two previously mentioned irrigation options.

When choosing either of the two watering modes, the system will always verify the existence of water in the reservoir tank. If there is no water, it will not execute the watering, and the LCD screen will warn us (Figure 6); otherwise, it will start the watering. In the form of automatic irrigation, the humidity, temperature, light and rain sensors (Figure 7) are in the range of Table 1. This is according to the plant, so the readings are appropriate, and the system can make accurate and convenient plant decisions.

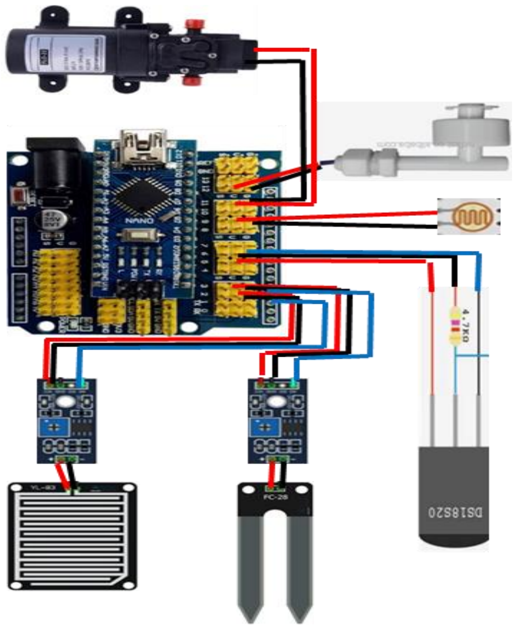

Fig. 4 Sensors installed on arduino board

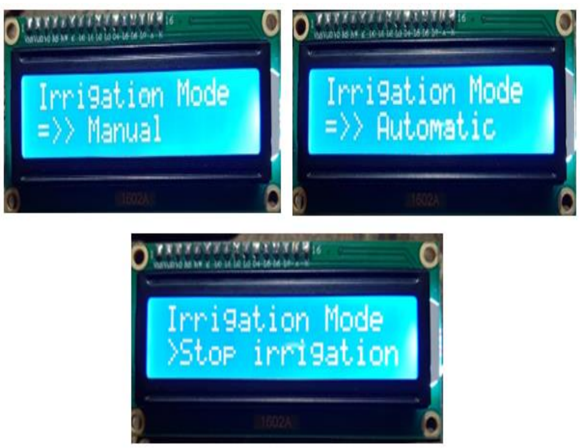

Fig. 5 Irrigation system menu

When choosing the "Manual" watering option, it will verify the existence of water in the reservoir tanks. If there is no water, it will show the message "Impossible to water, low water level, refill water tank" otherwise, it will start watering, and a message will be displayed, "Watering is being done manually" this action lasts for 10 minutes, after this time the water pump will automatically turn off, and watering will stop (Figure 8).

The application of the system was carried out in an area of approximately 1.65 m^2 (1.5 x 1.10 meters), with three ¼" PVC ducts and 5 holes of 1.2 mm per duct. It was determined that the water pump should work in an oscillating manner with a frequency of 10 seconds on for 10 seconds off so that the pump does not heat up because it is a small area for irrigation.

Fig. 6 Liquid level sensor message

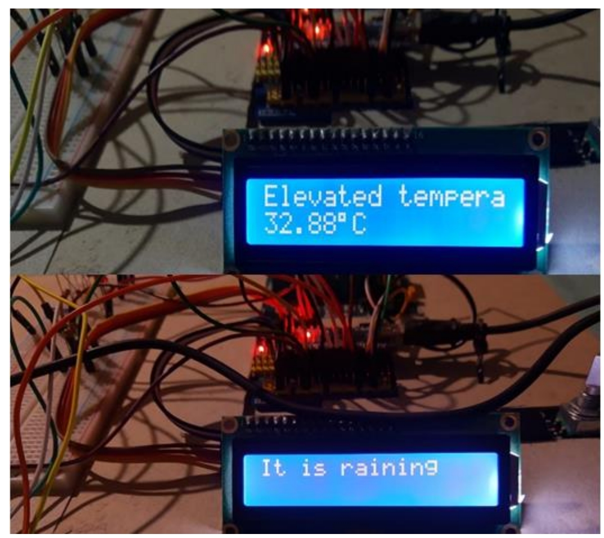

Fig. 7 Temperature and rain sensor message

The system, by default, is set to operate automatically, but it has the option to water manually, but it only lasts 3 minutes (depending on the area); also, if for some reason there is a water leak in the pipe or a dripper is clogged in the system there is an option to turn off irrigation that runs for both automatic and manual.

The intervention of a person is almost null in the tests were used with rosemary, roses and geranium plants in which the sensors (Figure 10) were in the range shown in Table 1. It is worth mentioning that, depending on the plant type, the sensors' working ranges will vary. Likewise, the tests using a 12-volt electric pump with an approximate flow of 3 liters per minute, with ¼" ducts with a run of 7.8 meters and 15 drippers of 1.2 mm, have an approximate consumption of 3.8 liters of water for irrigation. The system can keep the plants hydrated promptly and constantly when required.

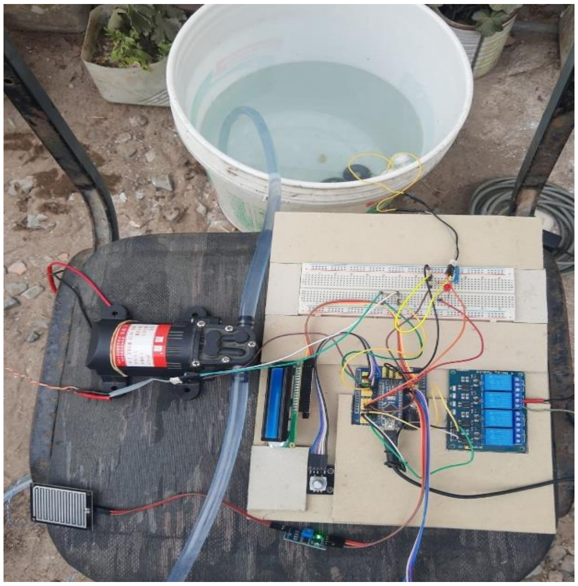

Fig. 8 System, water pump and water tank

Fig. 9 PVC ducts

Fig. 10 Temperature and humidity sensor on the crop

Table 1. Working range of sensors

Working range of components		
Sensors	**Active Irrigation**	**Disable Irrigation**
Humidity	>600	<=600
Temperature	<=19°C	>19°C
Light	0	1
Rain	>=650	<650

There are technified irrigation systems offered by companies dedicated to the field. However, their implementation is expensive, and there are even others that are published on the Internet. However, they do not use as many sensors to diagnose the conditions of the plant and weather conditions. A limitation in the implementation of the system is to set the parameters of the sensors, which depends directly on the type of plant.

The system can undergo modifications to make it more efficient. One of them is to expand the signal from the sensors to the control unit, which can cover more land, place an audible alarm to warn when there is no water in the tanks, and implement a database of the most used plants, which will record the parameters for each sensor.

4. Conclusion

This research presents an automatic technified irrigation system that uses sensors to determine the favorable weather conditions for drip irrigation to plants, executing it automatically without needing someone to implement it in order to save water consumption and make a good distribution of it, as well as reduce the consumption of fertilizer and fertilizers, in addition to improving the quality and increase production in agriculture, to generate a sustainable and environmentally responsible agriculture.

The system's development was used based on Arduino for having a variety of components and accessories. They are also easy to acquire, has an open-source programming language, and contain a variety of libraries for device control. The system is affordable because it is economical, technically reliable and because the system monitors at all times in real-time and has a power consumption of 5 and 12 volts of 0.5 and 1 Ampere, respectively. In future work, a plant database will be created with a record of parameters for the sensors, as well as improve the quality of the humidity sensor so that they have greater durability in the field.

References

[1] UNESCO, "Addressing Water Scarcity and Quality," *Ensuring Water Supply,* 2022. [Online]. Available: https://es.unesco.org/themes/garantizar-suministro-agua/hidrologia/escasez-calidad

[2] Feri Fadlin et al., "Spatial Modeling for Flood Risk Reduction in Wanggu Watershed, Kendari," *International Journal of Engineering Trends and Technology*, vol. 70, no. 12, pp. 219-226, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[3] Reni Oktaviani Tarru et al., "Spatial Distribution of Livestock Wastewater Pollution and its Treatment in Saddang Watershed," *International Journal of Engineering Trends and Technology*, vol. 70, no. 11, pp. 106-116, 2022. [CrossRef] [Publisher Link]

[4] Lorenzo Hurtado Leo, "*Irrigation Fundamentals*," La Molina National Agrarian University Agronomy Faculty, p. 72, 2016. [Google Scholar] [Publisher Link]

[5] L. Basso, E. de O. Medina, and J. Preciado Patiño, *Intelligent Agriculture*, 2013. [Online]. Available: http://www.iotsimple.com/agricultura-inteligente/

[6] United Nations, "Population | United Nations," *World Population Prospects*, 2019. [Online]. Available: https://www.un.org/es/global-issues/population (accessed Mar. 30, 2022).

[7] V. Cuzco et al., "Design and Implementation of an Automated and Wirelessly Controlled Irrigation System for a Farm Located in the Popular Sector of Balerio Estacio + cd," 2013.

[8] V. Del et al., La Molina Molina, pp. 10–12, 2019. [Online]. Available: http://repositorio.lamolina.edu.pe/bitstream/handle/UNALM/2131/L02-C389-T.pdf?sequence=1&isAllowed=y

[9] Leoncio Martinez Barrera, "*Fertirrigation Manual*," Gov. Reg. of Atacama, no. 56, 1998. [Publisher Link]

[10] T. Godhavari et al., "An Intelligent System for Monitoring Various Parameters in Irrigation System using IoT," *SSRG International Journal of Electrical and Electronics Engineering*, vol. 9, no.12, pp. 120-125, 2022. [CrossRef] [Publisher Link]

[11] Bonilla Segovia, J. S., et al., "Study of the Use of Artificial Intelligence Techniques Applied to Soil Analysis for the Agricultural Sector," *Reci World*, 16, 2021.

[12] Meghashree V et al., "Smart Village," *SSRG International Journal of Electronics and Communication Engineering*, vol. 7, no. 7, pp. 4-13, 2020. [CrossRef] [Publisher Link]

[13] Juan Antonio Castro Silva, "*Autonomous Irrigation System Based on the Internet of Things*," Master in Direction and Engineering of Websites, Neiva, Hulla, Colombia: International University of La Rioja, 2016. [Google Scholar] [Publisher Link]

[14] P. Cepeda et al., "Intelligent Greenhouse based on a Sustainable Approach for Mexican Agriculture," *CIINDET 2010*, pp. 1-8, 2015.

[15] Nitin Kumar Vishwakarma, Dr.Ragini Shukla, and Dr. Ravi Mishra, "A Review of Different Methods For Implementing Smart Agriculture on an Iot Platform," *SSRG International Journal of Computer Science and Engineering*, vol. 7, no. 12, pp. 5-8, 2020. [CrossRef] [Publisher Link]

[16] Grageda-Cabrera, O. A., Díaz Franco, A., and Peña Cabriales, J. J., "Impact of Biofertilizers in Agricultural," *Mexican Journal of Agrícultural*, pp. 1261-1278, 2018.

[17] Rajendra Akhil Kumar et al., "Crop Monitoring using Visual Sensors and IOT," *SSRG International Journal of Electronics and Communication Engineering*, vol. 4, no. 4, pp. 42-47, 2017. [CrossRef] [Publisher Link]

[18] F. R. Intriago Mendoza, "Agricultural Mechanization and is Impact on Agricultural Development in Ecuador," *Sahari*, p. 289, 2019.

[19] Davie B. Balmadrid, and Bobby D. Gerardo, "The Effects of Varying Dark Cycles and Pulse Width Modulation on Fresh Weight in Helianthus Annuus Microgreens," *International Journal of Engineering Trends and Technology*, vol. 70, no. 12, pp. 338-344, 2022. [CrossRef] [Publisher Link]

[20] Mulugeta Tadesse, and Chernet Merkneh, "Design of Solar PV Underground Water Pumping System for Household Water Consumption in Bilate Basin, Ethiopia," *International Journal of Engineering Trends and Technology*, vol. 68, no. 2, pp. 49-56, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[21] Ibrahim Naser, "Effect of the Leaf miners Flies on the Productivity of Field Crops Grown under Center Pivot Irrigation System," *SSRG International Journal of Agriculture & Environmental Science*, vol. 9, no. 3, pp. 10-16, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[22] Calderón, Á., and Camacho, A., "Access to Better Education and Technology Adoption in Agriculture," *Economy and Society*, pp. 48-51, 2016.

[23] M. Fernandez Donoso, "*Study and Development of Irrigation Water Efficiency Model Based on Agriculture 4.0. Study and Development of Irrigation Water Efficiency Model Based on Agriculture 4.0. Santiago De Chile*," Chile: Andres Bello University, 2020.

[24] L. Hurtado, "*Soil Management and Conservation*," Lima: National Agrarian University, 2016.

[25] P. Mooney, *Unsustainability Agriculture 4.0 - Digitization and Corporate Power in the Food Chain*, Mexico: Grupo ETC, 2020.