Architecture for Smart Irrigation System using Internet of Things

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ABSTRACT

The UAE fruits and vegetables market is expected to reach 6,376.9 million, with a CAGR of 9.34% during the forecast period (2019-2024) (Hashim et. al, 2019). The UAE is located in an arid desert environment characterized by its low rainfall rates and lack of freshwater resources such as rivers and lakes. The economic and population growth in the country in the past years have led to increasing the demand of domestic, industrial and agricultural sectors for groundwater resources therefore these resources began to decline sharply. The aim of current project is to present a system for innovative and smart agriculture. Thus, the researcher would like to provide a solution that can provide appropriate quantity of water and other nutrients to improve agriculture sector. The system designed monitors the sensor data, like moisture, humidity, temperature and ultrasonic The idea uses various types of sensors and IoT based techniques to accomplish the current aim. It will help in producing the crops that are healthier with less or no chemicals. The system is helpful to the society of UAE. It will also help to save environment by avoiding groundwater pollution. The feedback provided by the system will improve the implementation of the farming process."

Keywords: *Smart Irrigation, IoT, Green Desert*

INTRODUCTION:

The UAE fruits and vegetables market was valued at USD 3,731.0 million in 2018, and it is projected to reach USD 6,376.9 million, with a CAGR of 9.34% during the forecast period (2019-2024) (Hashim et. al, 2019). The drivers identified in this market are favorable government policies, an increase in consumption of fruits and vegetables due to health consciousness, and strong distribution and retail network. The restraints identified in this market are extreme climatic conditions and low domestic production. The majority of UAE economy depends on oil, but Fruits and vegetables market has a significant contribution to food security of the UAE. However, as climatic conditions of the UAE are not agricultural friendly, it has resulted in a high dependency on fruits and vegetables imports. According to Intelligence (2018), UAE spends 90% on the import of food and vegetables. Demand for in the coming years . This growth may increase disposable income and rapidly expand retail trade, all of which may, in turn, spur the growth of these products. The country has been making rigorous efforts through its five-year development plans, to improve the agricultural sector. This is likely to help diversify the sources of income, by reducing dependence on oil exports, and produce more food for the growing population with a high

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standard of living. Further agriculture provides not only the production of food but also raw materials in providing employment to the people. The UAE has a population of 8.6 million people, of which 88% are foreign citizens. There are twice as many men as women. The population is expected to reach 9.2 million by 2025 (Market Access Secretariat Global Analysis Report, 2017). This increased population will increase the demand for food in coming years. As a result, the pressure on import will increase and results in decrease GDP. Therefore, the aim of current paper is to provide an integrated system that will suit with the climatic conditions of UAE and help the farmers to produce crops with optimum usage of water, minerals and nutrients and increase sustainability of agriculture.

Automation of farm activities can transform agricultural domain from being manual and static to intelligent and dynamic leading to higher production with lesser human supervision. With rising population, there is a need for increased agricultural production. In order to support greater production in farms, the requirement of the amount of fresh water used in irrigation also rises. Unplanned use of water inadvertently results in wastage of water. Although conventional irrigation methods like spray irrigation appears to be the fastest and cheapest, there are larger hidden costs and 60

percentage of water evaporates before being absorbed by the plants (Susila, & Minu, 2019). This decrease in water coupled with uneven distribution effects the plant health. Drip irrigation that uses perforated tubes buried near the roots of plants involves digging the soil. It does not ensure controlled amount of water flow to the roots.

The underground hose irrigation system minimizes water wastage without distributing nutrient balance. Though there is no need to fertilize the garden often, this method does not ensure optimum level of fertilizers diffused with the water. Automatic irrigation system triggers an excess supply of water that is not needed. There is a need for an irrigation system that not only controls the water level and monitors the optimum level of fertilizers depending on the plant and soil conditions. The initiative is relevant because agriculture related sectors consume about 75% of total water consumption according to the environmental agency (Hammadi, 2015). Moreover, 80% of land is desert in UAE (Hammadi, 2015). As a result, government spend lot of money on the export of food. This results in loss of foreign revenue. This also affect the prices of food products which is quite high. The source of food is unknown to the customer. Sometimes, the food contains too many pesticides and other chemicals that are very harmful for the

customers. These problems suggest that there is an urgent need to develop a system that make efficient use of water, increase sustainability of agriculture, reduce power consumption and provide healthy food without imposing pressure on farmers.

LITERATURE REVIEW

In agriculture, crop output and yield play a crucial role. In order to increase crop productivity at a lower cost, it is necessary to consider aspects such as temporal and spatial variability. In such a setting, the name Farming System (FS) occurs in crop management. According to the National Research Council (Quigley, 2019), the agricultural development and management of a field are dependent on the site or soil conditions. Segarra (2004) mentioned that the accurate application of water and agrochemicals to suitable soils reduces environmental pollution. The UAE government has made a number of measures to enhance agriculture. Monitoring soil parameters is the most significant component of agriculture since it has a direct impact on field crop production and upkeep. Soil factors such as moisture content, temperature, humidity, pH, and other minerals play a crucial role in determining the cost of agricultural production and enhancing yield. Using Wi-Fi-connected sensors, it is possible to do real-time

monitoring of these characteristics. This method is covered by Internet of Things research (IoT). In the past, timers and switches were employed to control the ON and OFF states of the irrigation systems water delivery motor. Modern mobile phone technology and the expansion of 3G and 4G networks to rural areas facilitate the monitoring and control of agricultural factors using IoT technology (Madushanki, Halgamuge, Wirasagoda, & Ali, 2019). The IoT connects objects to the internet so they can communicate with sensing devices using appropriate protocols and exchange data utilizing wireless sensor networks. Using the IoT, several parameters are monitored in real time and on a regular basis. IoT provides information across many industries, including agriculture, healthcare, and household appliances4. The Internet of Things, cloud computing, and block chain technologies offer new prospects for IoT-based applications and services.

In this regard, the objective of current project is to provide a working computer-controlled irrigation system which allows precise control of the quantity of water and amount of minerals to the soil to fulfil the requirements of any crop to build a green environment in a sustainable framework. The main objective of the current project is to have a smart system that will take care of watering plants automatically at appropriate

time, as and when the plant needs it. Moreover, the system will provide appropriate quantity of nutrients required by plants.

IDEA

Identify soil composition to be utilized for the appropriate crops and provide the required amount of water and optimum quantity of minerals required for the specific type of agriculture.

- **Environmental Objectives**
  - Reduce water usage.
  - Control and minimize the use of chemicals to prevent groundwater pollution.
  - Assist authorities to assign standards about chemicals usages in each farm.
- **Health Objectives**
  - Produce natural and healthy crops.
  - Produce high quality crops that with be certified by authorities.
- **Economic Objectives**
  - Local products have a low price because of the usage of chemicals which reflect an inferior reputation to the farmer and its profession.

  - Crops approved by authorities will affect the prices of the products.
  - Save time and efforts and know the appropriate price for the soil.

CHALLENGES

Knowledge of soil water content is crucial for improving irrigation efficiency through water management. Plant growth is inhibited by soil with inadequate or excessive moisture. Soils with significant wetness have poor aeration because water fills the soil's pores. In such soils, roots tend to develop towards the surface. A tree whose roots are inadequately grounded is prone to wind throw. A tree may survive for a time, but eventually its roots will die and degrade due to a lack of oxygen in the soil, leaving it unable to absorb water and nutrients. Similarly, soil with a low or insufficient water content has an impact on plant growth and agricultural yield. Frequently, building and planting activities, such as the incorrect use of irrigation systems, result in excessive soil moisture. Nevertheless, some areas are inherently prone to soil saturation due to soil type, geography, severe rainfall, flooding, or a high water table. For instance, clay-rich soils tend to have more drainage issues than sandy soils because they are more prone to compaction. Therefore, it is crucial to deliver

adequate water to plants at the proper time. In addition, excessive pesticides and a lack of efficient nutrients are detrimental to the soil and plant growth. This will influence not just us, but also future generations. This is one of the reasons why organic products should be chosen.

Most farmers do not take irrigation water nutrient concentrations into account while fertilizing. This source of plant nutrients is essential and can save farmers money and prevent field toxicity caused by the application of large quantities of these components. Therefore, the concentration of these nutrients in irrigation water should be tested and accounted for; additionally, adding more than one type of nutrition that the soil requires will result in healthier soil that aids in plant growth; nutrition security has been viewed as the province of health professionals. Nevertheless, the nutrition problem cannot be resolved exclusively by the health sector: farmers are the primary providers of nutrients, and the entire agriculture food chain plays a crucial role. Food security objectives, including nutrition security, cannot be attained without a continued emphasis on agricultural productivity improvement.

The project will be useful for the UAE as the UAE government is putting lot of efforts for the quality of life to be provided to all the people residing in UAE. The project also includes usage of sunlight which is one of the renewable source of energy available in UAE in plenty.

The UAE is located in an arid desert environment characterized by its low rainfall rates and lack of freshwater resources such as rivers and lakes. The economic and population growth in the country in the past years have led to increasing the demand of domestic, industrial and agricultural sectors for groundwater resources therefore these resources began to decline sharply. The main factors that cause agricultural issues in the UAE can be classified as the following:

1) Humidity: It is important to maintain a certain level of humidity for optimum plant growth. Humid air is associated with foliar and root diseases. More pesticides are needed for disease control making the plant less desirable. High humidity is a problem because water usage by the plant is too slow. Likewise, very low humidity is a problem because it slows photosynthesis and plant growth (Chikamatsu et. al,, 2020).

Humidity Too Low	Humidity Too High
Wilting	Soft growth
Stunted plants	Increased foliar disease
Smaller leaf size	Nutrient deficiencies
Leaf curl	Increased root disease
Dry tip burn	Oedema
spider mites Increased infestation	Edge burn (guttation)

Figure 1 Effect of high and low humidity on plant growth

1) High temperature: Temperature is a primary factor affecting the rate of plant development. Extreme temperature influences productivity of agricultural plants. Both too high and too low temperatures spoil a sequence of biochemical processes in cells, these changes lead to a stop of growth and death of plants. (Marschallinger et. al, 2018)

2) Wasting water: Freshwater is an essential resource for survival. In the UAE Irrigated agriculture is the primary water consumer, with an average of around 60% of total water use, where 39% is used for productive agriculture, 11% used for greening and landscaping and 10% for forestry. The amount of municipal use for household and industrial purposes is 40% of total water consumption. Irrigation water is generally used in a wasteful manner, mainly through traditional flooding and furrow irrigation techniques and for cultivating low-value, high-water-consumption crops (Alsharhan, & Rizk, 2020).

3) Dubai Electricity and Water Authority (DEWA) last annual report for 2017 showed that number of water consumers increased in 2017 so did the water consumption, figure 2 illiterates the most recent statistics for water consumption in Dubai (DEWA, 2017).
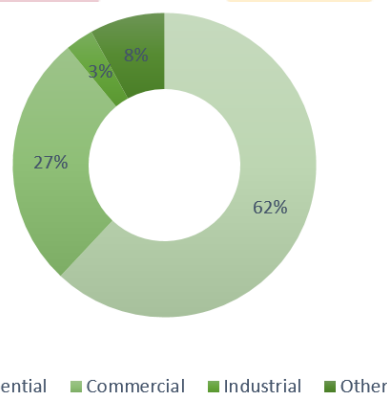
Figure 2 Water consumption by sector in Dubai (2017)

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4) Groundwater pollution: Groundwater was one of the main water sources in the UAE, but due to rapid expansion in agricultural areas and excessive water abstraction for farming there was a sharp drop in water levels in freshwater aquifers which resulted in increased salinity and chemicals. Groundwater pollution is caused by several factors including seawater intrusion and heavy application of chemicals (Alsharhan, & Rizk, 2020).

5) Soil Classification and PH Measurements: Soil texture is the most important soil characteristic to assess physical properties. Soil pH measures the degree of soil alkalinity or acidity, which plays an important role in controlling nutrient availability and fixation in soil.

PROCEDURAL IMPLEMENTATION OF THE IDEA

Current project aim is innovative agriculture. Thus, the researcher would like to deliver solutions for water scarcity with appropriate quantity of nutrients to improve agriculture sector and develop smart irrigation system using sensors. Different plants need different conditions for growth, the sensors will study the soil and its composition to provide any plant with its optimal conditions for its growth.

The researcher would like to introduce computer-controlled irrigation system which allows precise control of the quantity and amount of nutrients to irrigation water and supplies to any part of the farm. The system will analyze the mineral levels in soil such as Potassium, Sodium, Phosphorus etc. to determine the soil's quality then provide the plants with the required minerals to maintain optimum growth and reproduction.

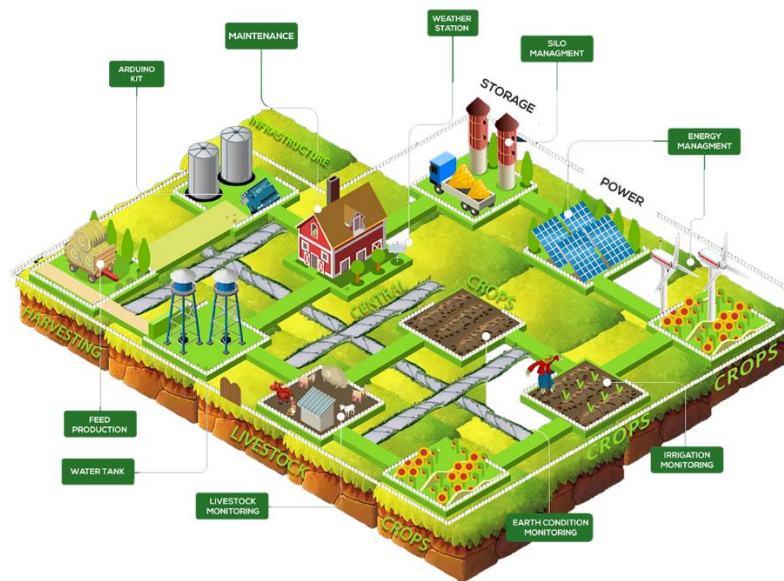The following diagram explains the functionality of the whole system;

Figure 3 Smart Irrigation Functionality Diagram

Typically, the modern intelligent system comprises a central controller to which other devices are connected. The smart garden consists of a central hub to which a variety of sensors, including moisture sensors, humidity sensors, temperature sensors, and ultrasonic sensors, are linked. Connected to a water tank, the ultrasonic sensor indicated the water level in the tank. Other sensors are connected to their appropriate locations, and these sensors transmit data to a centralized hub equipped with Wi-Fi technology. Also attached is a database in which the sensor's real-time values are updated every second. It provides analytics, databases, messaging, and reporting capabilities. Database integration with Android and the web is simple. Mobile application is coupled with the database for control purposes. Android studio is used to develop Android applications. The connection between the application and database will be established within the software. Therefore, the user can monitor the parameters remotely. How a garden is watered depends on the type of soil. Therefore, the values of the sensors are predetermined within the software for automation reasons. This contributes to the overall care of the farm.
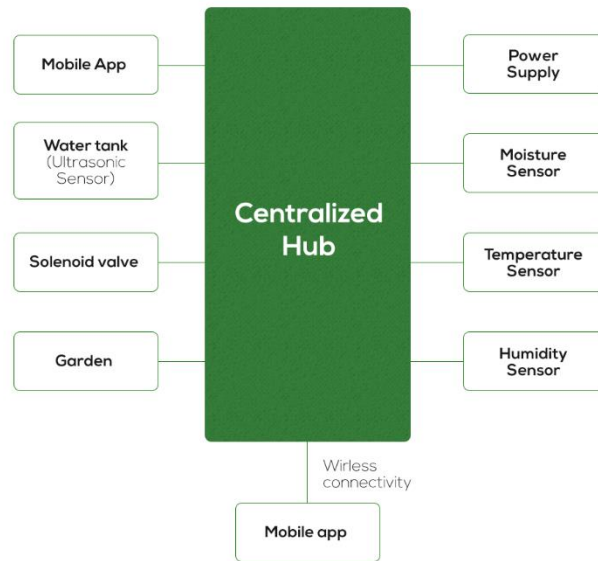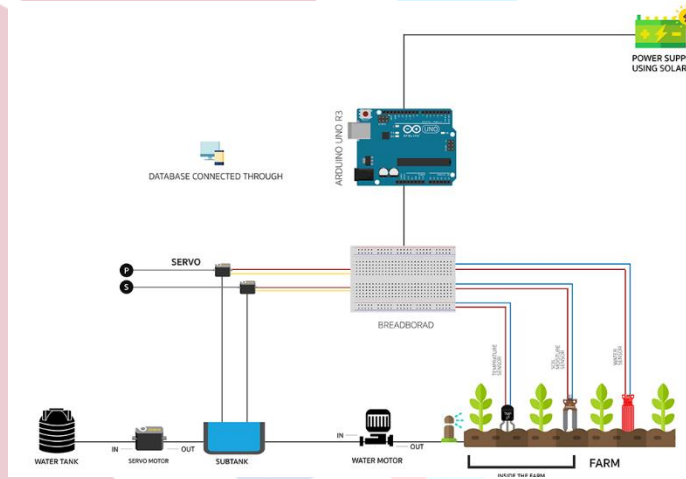
Figure 4 Block Diagram of smart Irrigation System

Figure 5 Technical Design of Smart Irrigation System

The devices which converts the electrical signals into digital signals are known as sensors. The different types of sensors incorporated in this system are listed below.

• Humidity sensor – used to measure the humidity content of the soil.

• Temperature sensor – used to measure the temperature of the soil.

• Ultrasonic sensor – used to measure the water level in the tank.

• Moisture sensor – used to measure the moisture content of the soil.

• Soil Nutrient Sensor- used to measure the percentage of nutrient of the soil.

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The sensors will check the moisture and nutrients of the soil. The same information will be used to check whether the available quantity of water and nutrient is sufficient or not. If the quantity is less then acceptable range or value, the nutrients and water will be supplied automatically. The solar panel is used to get required energy. The whole system can be monitored and controlled remotely through the mobile application. The system has a good database which contains all the information related to the type of soil and crop that can be grown in the soil. Therefore, this information can be used by farmers to know what kind of crop can be grown in the soil based on given soil and environment conditions. Below are the few screen shots of the mobile application. Some of the smart irrigation system's usefulness can be summarized with the following points:

- Smart sensors can measure all minerals needed by the plant and accurately provide it with its needs, it can even measure the water level required by the plant, and it can keep away all the pesticides (crows etc.) that might damage on the plant.
- Have remote access to the farm with an ability to control from a screen.

- Farmers can learn from the system which can lead to a new scope in the field of combining farmers and technology.
- Provide advice about farming according to the year's seasons.
- Save the farm monthly data on the application through sensors to record improvement, generate reports about the farm's status, and maintain crops throughout the year.
- Assist people who are new to farming to get more knowledge about farming through this new technology.
- Generate farming business and boom its economy.

Setting irrigation systems to deliver water based on need, instead of time, will help prevent excessive soil moisture. At the same time, the system is economic and environmental friendly as it uses sunlight as a source of electricity. Especially in UAE where the country has lot of natural renewable source of energy that is sunlight. The idea is to use that ample sunlight to generate and store energy for the system. The system will help to transform the desert into green. The benefits of the system can be summarized in the following diagram.
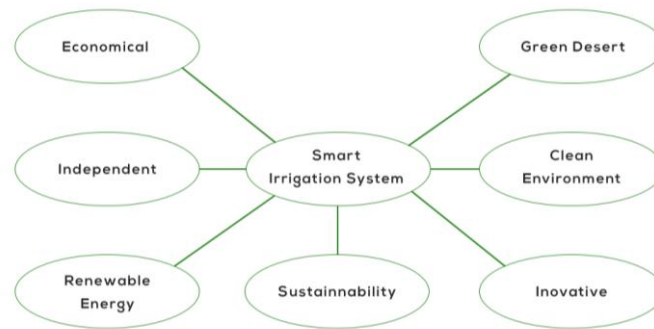
Figure 6 Benefits of smart Irrigation System

CONCLUSION

The current smart irrigation system is innovative as it combines technology and farming techniques. The implementation of Smart Irrigation system has been verified to satisfactorily work by connecting different parameters of the soil and was successfully controlled remotely through a mobile application and desktop application. The system designed not only monitors the sensor data, like moisture, humidity, temperature and ultrasonic but also actuates other parameters according to the requirement, for example, if the water level in the soil is reached to sufficient level then the motor switch is turned off automatically.

This system can therefore be installed anywhere due to its low startup cost and installation price. With the advancement of sensor technology, the system can be taken to the next level, enabling customers to utilize their investments more efficiently.

If soil nutrient sensors can be fitted, then the system can be changed to deliver accurate amounts of fertilizer to the farm. This technology reduces labor costs and optimizes the use of existing water resources, resulting to an increase in profits. Moreover. It will help in producing the crops that are healthier with less or no chemicals. In this way, the system is helpful to the society of UAE. At the same time, it will also help to save environment by avoiding Groundwater pollution. The feedback provided by the system will improve the implementation of the agriculture process.

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