IT4010 – Research Project - 2023

Topic Assessment Form

Project ID : TMP-23-344

1. Topic (12 words max)

Smart Aquaponics System

2. Research group the project belongs to

Computing for Inclusive and Equitable Society (CIEC)

3. Research area the project belongs to

ICT for Development (ICTD)

4. If a continuation of a previous project:

Project ID	
Year	

5. Team member details

Student Name	Student ID	Specialization
Leader: Ubayasena W.P.H	IT20167332	IT
Member 2: Hemantha N.S.C	IT20131838	IT
Member 3: Wijayakoon W.M.T.B	IT20167950	IT
Member 4: Kavindya R.M.N	IT20192228	IT

6. Brief description of the research problem including references (200 – 500 words max) – references not included in word count

Aquaponics has become a trending technology for those that are looking to adopt and develop sustainable and environmentally friendly food production systems [3].

- Traditional aquaponic systems rely heavily on intervention by the farmer to maintain optimal water quality levels and manual monitoring. However, this approach can be time-consuming and labor-intensive, which can lead to inconsistencies in water quality management. water quality Parameters describe in [4], Additionally, traditional systems may not be equipped to generate warnings or instructions to the farmer. Control of water quality parameters in aquaponic systems presents a unique challenge due to the time required to adjust parameters such as pH, ammonia, nutrition, and dissolved oxygen levels [4]. Failure to adjust these parameters in a timely manner can have detrimental effects on both fish and plant growth and it described in [1].
- Most aquaponic systems and aquaculture systems do have not a proper system for giving a fish feed. They are using manual methods for giving feed to fish. They face some difficulties because lack of a proper method. They need human resources to do this job. Then they waste an additional cost, an additional time-consuming and an effort for this job. Most of them decide the quantity of fish feed they need, from their experience. Sometimes they do not know how much fish feed fish need at consider time. They have no methods for measuring these things.
- Aquaponic farming is a sustainable agricultural system that combines aquaculture and hydroponics to produce both fish and crops with minimal water consumption and environmental harm [7]. Nonetheless, the nutrient content of water in such systems can influence crop growth, leading to nutrient deficiencies [8]. Early detection of such deficiencies can minimize crop damage and allow for immediate corrective measures. As a solution, we suggest utilizing image processing techniques to identify nutrient deficiencies in aquaponic farming [9].
- The demand for and pricing of various organic food goods change. People's dietary requirements differ with time. Food crops grown in different seasons changes as well. At times, the demand for foods increases dramatically, while others decrease dramatically. Because these aspects are unknown, food items that are in short supply during certain seasons are farmed. As a result, some farmers are unable to sell their produce. As a result, a considerable amount of food is wasted. There is one more thing that is extremely crucial.

References

[1] A. Reyes Yanes, "Towards Aquaponics 4.0: A Framework for Automation, IoT, and Smart Systems Implementations in Indoor Farming," University of Alberta, 2020.

[2] A. B. a. P. Devi, "Water quality guidelines for the management of pond fish culture," 2013.

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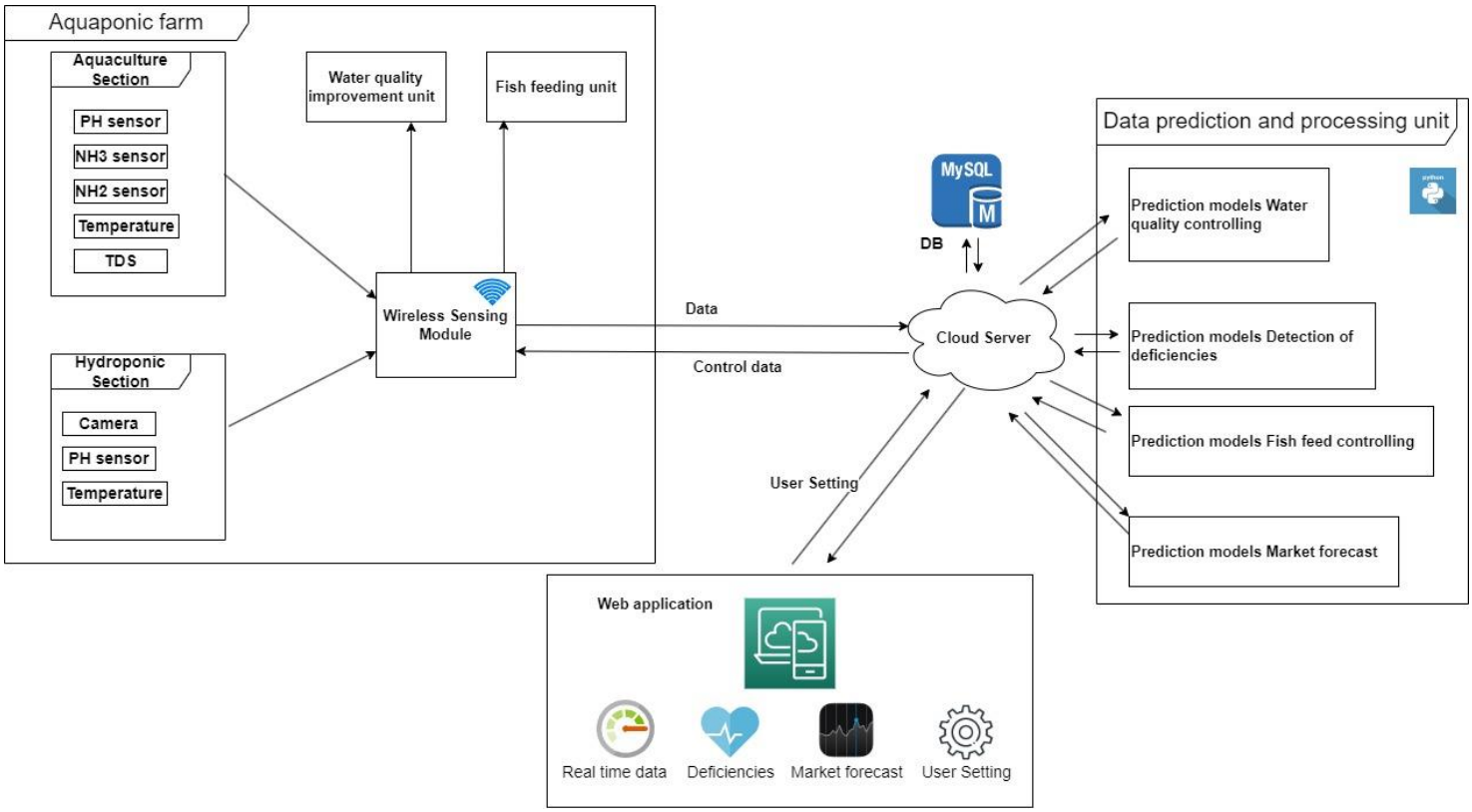
[12] "Organic Food Market by Food Type (Fruit & Vegetables, Meat, Fish & Poultry, Dairy Products, Frozen & Processed Foods, and Others) and Regional Analysis (North America, Europe, Asia-Pacific, and LAMEA)," Global Opportunity Analysis and Industry Forecast, 2022.

7. Brief description of the nature of the solution including a conceptual diagram (250 words max)



The IoT systems in the aquaponic farm are connected to a cloud-based system that receives real-time data from sub-IoT systems. Cloud-based system can handle many farms. The cloud system utilizes cloud services to predict system configurations and identify critical moments in the aquaponic system. These predictions are transmitted to IoT devices, enabling automatic control of variables like nutrient levels, fish feed, water quality, light, and water flow. The cloud-based system communicates predicted instructions and relevant information to the user's web application. Because of Cloud-based system this system can reduce cost when installing new aquaponic farm. 4 models to predict water quality, fish feed , nutrient deficiencies detect and market forecast.

- A new smart aquaponic system has been developed that can automatically monitor and maintain water quality levels while generating real-time warnings and instructions for the farmer. This system incorporates sensors to monitor key water quality parameters such as pH, ammonia, nitrite, and total dissolved solids (TDS) [2]. The sensors relay this data to a central controller, which can automatically adjust the system's water flow and nutrient delivery to maintain optimal conditions for both fish and plants for example system should be able to maintain 6 to7.5 PH level and nitrite 50-100ppm. optimal conditions explain in [1]. Other water quality prediction model studies they used Artificial neural network which is a well-developed machine learning model with high nonlinear fitting ability and self-learning ability [5].

- We consider some parameters for measuring these things (pH value, ammonium level, water temperature). We develop a device to give feed to the fish at the correct time. We have methods for managing the quantity of fish feed and how many fish need at a considered time. Then we can reduce the cost, effort, human resources, and wasted fish feed using this automatic system. Aquaponic farming is a system that integrates aquaculture and hydroponics to create a closed-loop system [10] [11]. The system allows to produce both fish and crops with minimal water usage and environmental impact. However, the nutritional level of water in such systems can significantly impact crop growth, and nutrient deficiencies can arise. Identifying these deficiencies early can help mitigate the damage to crops and allow for prompt corrective measures. We propose the use of image processing to identify nutrient deficiencies in aquaponic farming.

- Image processing can be a valuable tool for detecting nutrient deficiencies in lettuce. By analyzing images of the plants, it is possible to identify visual cues that indicate a deficiency. For example, leaf color, shape, size, and texture can all be used as indicators of nutrient deficiencies. By training image processing algorithms on a large dataset of healthy and deficient lettuce plants, it is possible to develop a reliable system for detecting nutrient deficiencies in real-time.it is necessary to collect a dataset of images of lettuce plants that have been grown under varying nutrient conditions. Next, the images need to be processed using image segmentation and feature extraction techniques to isolate and analyze the relevant features of the plant. Finally, a machine learning algorithm and utilizes a convolutional neural network can be trained on this dataset to accurately classify lettuce plants based on their nutrient status [6].

- In the Market forecasting, need to know about the price behavior of some food items in the future. There is a solution by develop a system for predicting the future demand for organic foods and products that fail at the market in the related seasons, situations, etc. [12] [13]... We can guess the future prices of organic foods using this system. The survey is included for this market forecasting component.

References

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8. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

We are hoping to develop a smart aquaponics system. By applying IoT, machine learning, and image processing-based approaches. An IoT system consisting of an ESP-32 microcontroller that controls water quality sensors in aquaponics fishponds and poly tunnel was designed and developed for automatic data collection. The sensors include temperature, pH, dissolved oxygen, turbidity, ammonia, and nitrate sensors. We save real-time collecting data using cloud technology.

The IoT systems situated within the aquaponic farm are linked to the cloud-based system. Real-time data from the sub-IoT systems is transmitted to the cloud system, which utilizes cloud services to predict system configurations and identify critical moments in an aquaponic system. These predictions are subsequently relayed to IoT devices, allowing farms to automatically set their control variables include nutrient levels, fish feed, water quality, light, and water flow within the aquaponic system. The main cloud-based system also communicates predicted instructions and relevant information to the user's web application in parallel with the aforementioned process. To train a model for water quality and fish feeding, a dataset from Kaggle will be utilized [1].

There is a correlation between the nutritional level of water in an aquaponic farm and the growth of crops, as low nutritional levels can result in deficiencies. However, through the application of image processing techniques, it is possible to identify and analyze these deficiencies. To train a model for detecting nutrient deficiencies, a dataset from Kaggle will be utilized [2].

Simultaneously, the system is capable of conducting market forecasting and analysis through the utilization of a machine-learning model. Subsequently, the system is able to generate predictions of future market demands for crops.

To apply machine learning and approach, we collect reliable data sets from the Kaggle [1]. In addition to that, for development perspective we agreed to develop web application using "Angular" with the support of “NodeJS” backend, “AWS” and relevant database approaches (SQL).

[1] C.N. Udanor, N.I. Ossai, E.O Ogbuokiri, C.H Ugwuishiwu, S.O Aneke , “An internet of things labelled dataset for aquaponics fish pond water quality monitoring system,” 2019. [Online]. Available: https://www.data-in-brief.com/article/S2352-3409(22)00597-2/fulltext#seccesectitle0002 https://www.kaggle.com/datasets/ogbuokiriblessing/sensor-based-aquaponics-fish-pond-datasets

[2] https://www.kaggle.com/datasets/baronn/lettuce-npk-dataset https://www.kaggle.com/datasets/hkleeeee/lettuce?select=lettu.csv

9. Objectives and Novelty

Main Objective
Develop a system to encourage the use of automation, computer vision and IoT technologies in the enhancement and widespread adoption of this farming technology as a reliable, feasible, sustainable, efficient and greener option for food production.

Member Name	Sub Objective	Tasks	Novelty
Ubayasena W.P.H	Water quality controlling	• Identify Which parameters are involved in Aquaponics, and which ones can control, monitor, and/or predict aquaponics system behavior to reduce manual labor. • Develop IoT system for collect and save real time data. • Machine learning based approach to predict the results of real-time accurate water quality prediction. • Develop a mechanism to control water quality based on prediction data.	Most of the systems and research have been developed to monitor and regulate water quality based on sensor data. And some research has been explored using machine learning based, but they cannot detect water quality parameters until those are changed [1] [2]. However, the control of water quality parameters in aquaponic systems presents a unique challenge due to the time required to adjust parameters such as pH, ammonia, nutrition, dissolved oxygen, and calcium levels. Failure to adjust these parameters in a timely manner can have detrimental effects on both fish and plant growth. To address this challenge, we are going to use neural Network training model and predicting water quality parameters before they reach critical levels. This proactive approach enables the optimization of the aquaponic system, resulting in improved. efficiency, higher yields, and increased sustainability. This study specifically addresses the optimization of the top two nutrients (ammonium and

			calcium), which should be regulated depending on the month in which the plants and fish are grown in a closed-loop control aquaponic set up.
Hemantha N.S.C	Detection of nutrient deficiencies	• An image processing-based approach to detect plant deficiencies involves capturing digital images of plants and analyzing them using image processing to identify any visual abnormalities or patterns that may indicate a deficiency. • Suggest nutrient treatments for aquaponic farming. Adding specific nutrients to the system to address nutrient deficiencies in plants.	While previous research has explored nutrient deficiency detection in traditional soil-based farming systems, there is a lack of research on the topic in aquaponic farming systems. This is significant because aquaponic systems present unique challenges and opportunities for nutrient management, and understanding how to detect and prevent nutrient deficiencies in this context is crucial for the success and sustainability of the system. To address this gap, a new model has been developed based on deep learning techniques and utilizes a convolutional neural network to classify images of crops based on their nutrient content. This approach has the potential to address the way nutrient deficiencies are detected and managed in aquaponic farming systems.
Wijayakoon W.M.T.B	Fish feed management	• Machine learning based approach to predict the weight of feeds fish need. • Predict the correct time for put the feed to the water from measure temperature and pH of water.	The manual control of fish feeding in aquaponics systems has various drawbacks, including inconsistency in food quantity, time-consuming and labor-intensive work, the potential for human error, and limited ability to monitor and adjust nutrient levels. To overcome these issues, farmers are turning to automated feeding systems which ensure

			consistent and accurate feeding and improve system efficiency. The integration of machine learning and automation in fish feeding offers various benefits such as consistent and accurate feeding, labor savings, efficient nutrient management, continuous optimization, and real-time data and insights. As a result, machine learning and automated fish feeding can improve the overall performance of aquaponics systems and increase yields, health, product quality, and profitability for the farm. Earlier researches did not do like this automatic fish feed mechanism.
Kavindya R.M.N	Market analysis	• Machine learning based approach to detect future demand of the products. • Conduct a survey for find suitable market. • Find suitable customers for sell final products and by-products.	There was no mention of market analysis in the systems that existed until now. But this system also includes market forecasting and analysis. Therefore, based on product data, quantity data, cost data, sales data, etc., it is possible to reduce the cost and risk of the farmer due to over selling or unsold product. Earlier researches are not mention toughly about how to change the demand of organic food depends on seasons and situations.

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Topic Assessment Form

10. Supervisor checklist (supervisors should fill sections 10 and 11)

a) Is this research problem valid?

Yes	✓	No	

b) Is the proposed research group correct?

Yes	✓	No	

c) Is the proposed research area correct?

Yes	✓	No	

d) Do the proposed sub-objectives match the students' specialization?

Yes	✓	No	

e) Is the required domain expertise, knowledge, and the data available either through the supervisor or external supervisor?

Yes	✓	No	

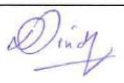
f) Is the scope of the solution practical?

Yes	✓	No	

g) Do all sub-objectives have sufficient novelty?

Yes	✓	No	

11. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Ms.	Vindhya	Kalapuge	
Co-Supervisor	Ms.	Piyumika	Samarasekara	
External Supervisor	Mr.	Heshan	Fernando	
Summary of external supervisor's (if any) experience and expertise (CEng, BEng, (Hons)UK) Founder, MD, Aquaponics SL (Since 2016) MD, Hilldale Retreat (Pvt) Ltd.				

Summary Sheet

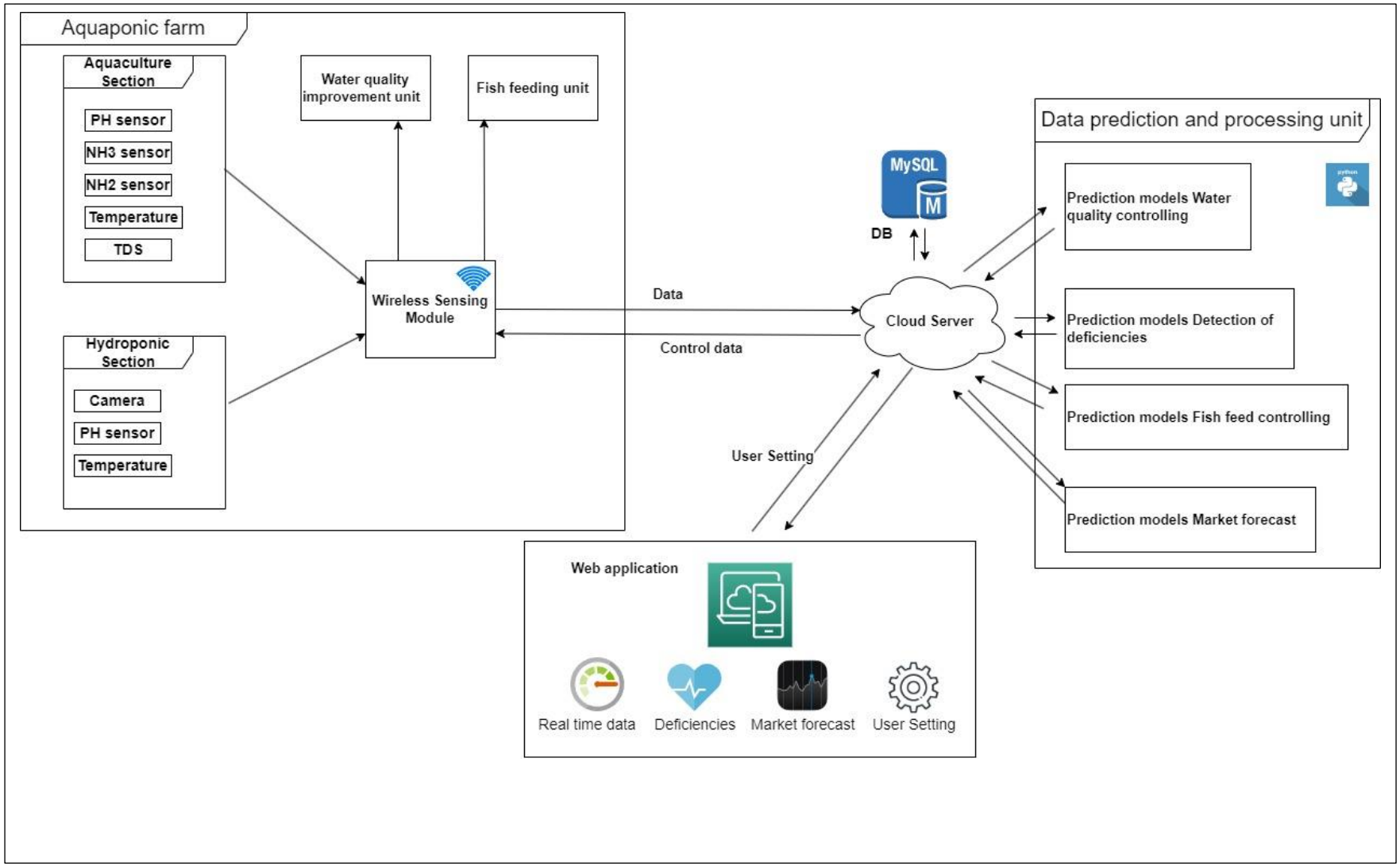
The topic evaluation panel will use the summary sheet to evaluate the suitability of the project

1. Brief description of research problem including references (200 – 300 words max)

Aquaponics has become a trending technology for those that are looking to adopt and develop sustainable and environmentally friendly food production systems [3].

- Traditional aquaponic systems rely heavily on intervention by the farmer to maintain optimal water quality levels and manual monitoring. However, this approach can be time-consuming and labor-intensive, which can lead to inconsistencies in water quality management. water quality Parameters describe in [4], Additionally, traditional systems may not be equipped to generate warnings or instructions to the farmer. Control of water quality parameters in aquaponic systems presents a unique challenge due to the time required to adjust parameters such as pH, ammonia, nutrition, and dissolved oxygen levels [4]. Failure to adjust these parameters in a timely manner can have detrimental effects on both fish and plant growth and it described in [1].
- Most aquaponic systems and aquaculture systems do have not a proper system for giving a fish feed. They are using manual methods for giving feed to fish. They face some difficulties because lack of a proper method. They need human resources to do this job. Then they waste an additional cost, an additional time-consuming and an effort for this job. Most of them decide the quantity of fish feed they need, from their experience. Sometimes they do not know how much fish feed fish need at consider time. They have no methods for measuring these things.
- Aquaponic farming is a sustainable agricultural system that combines aquaculture and hydroponics to produce both fish and crops with minimal water consumption and environmental harm [7]. Nonetheless, the nutrient content of water in such systems can influence crop growth, leading to nutrient deficiencies [8]. Early detection of such deficiencies can minimize crop damage and allow for immediate corrective measures. As a solution, we suggest utilizing image processing techniques to identify nutrient deficiencies in aquaponic farming [9].
- The demand for and pricing of various organic food goods change. People's dietary requirements differ with time. Food crops grown in different seasons changes as well. At times, the demand for foods increases dramatically, while others decrease dramatically. Because these aspects are unknown, food items that are in short supply during certain seasons are farmed. As a result, some farmers are unable to sell their produce. As a result, a considerable amount of food is wasted. There is one more thing that is extremely crucial.

2. Brief description of the nature of the solution (150 words max)



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- this system can monitor water quality levels pH, ammonia, nutrition, dissolved oxygen, and calcium levels. and generate real-time warnings and instructions using sensors data and water quality artificial neural network prediction model. using this data, It can maintain optimal conditions for fish and plants.
- In fish feed component we propose the use of a device that measures pH value, ammonium level, and water temperature to feed fish at the correct time and manage the quantity of fish feed. This automated system reduces costs, effort, human resources, and wasted fish feed.
- Image processing can detect nutrient deficiencies in lettuce by analyzing visual cues such as leaf color, shape, size, and texture. To develop a reliable system, a dataset of healthy and deficient lettuce plants must be collected and processed using image segmentation and feature extraction techniques. A machine learning algorithm can then be trained to classify lettuce plants based on nutrient status in real-time.
- In the Market forecasting, need to know about the price behavior of some food items in the future. There is a solution by develop a system for predicting the future demand for organic foods and products that fail at the market in the related seasons, situations, etc. [12] [13]... We can guess the future prices of organic foods using this system. The survey is included for this market forecasting component.

3. Objectives and novelty

<table>
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Topic Assessment Form

<u>This part to be filled by the Topic Screening Panel members</u>

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes (should be followed up by the supervisor)*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

The Review Panel Details

Member's Name	Signature

Important:

1. According to the comments given by the panel, do the necessary modifications and get the approval by the **Supervisor** or the **Same Panel**.
2. If the project topic is rejected, identify a new topic, and request the RP Team for a new topic assessment.
3. The form approved by the panel must be attached to the **Project Charter Form**.