Article **Journal of Systematic Innovation**
December 2023 Vol.7 No.21 7-17

Smart solar hydroponic system simulation

Simulación de sistema hidroponico solar e inteligente

PONCE-GONZALEZ, Cristopher†, ANTONIO-ANTONIO, Alejandrina*, MERINO-TREVIÑO, Marco, Antonio and PEÑA-DELGADO, Adrián Fermín

Universidad Tecnológica de Altamira

ID 1st Author: *Cristopher, Ponce- González /* **ORC ID**: 0009-0007-4730-8845, **CVU CONAHCYT ID**: 1309741

ID 1st Co-author: *Alejandrina, Antonio-Antonio* / **ORC ID**: 0000-0002-7578-6330, **CVU CONAHCYT ID**: 947482

ID 2nd Co-author: *Marco Antonio, Merino-Treviño* / **ORC ID**: 0000-0001-8901-5054**, CVU CONAHCYT ID**: 295355

ID 3rd Co-author: *Adrián Fermín, Peña-Delgado* / **ORC ID**: 0000-0002-4922-414X, **CVU CONAHCYT ID:** 174744

DOI: 10.35429/JSI.2023.21.7.7.17 Received July 14, 2023; Accepted June 29, 2023

Abstract

This project "Simulation of Intelligent Solar Hydroponic System" aims to provide a possible alternative for the generation of food resources that can be consumed in the University community and in the town of Altamira Tamaulipas. The project schedule was divided into three stages, Stage 1: involved research and training, Stage 2: followed by simulations and research formats. stage 3: consisted of refining the details and planning the presentation virtually. In this way, the evaluation and feedback of the project was carried out, it involved the review of the objectives and goals of the project, the simulation test to ensure adequate functionality, the analysis of the project methodology, the review of the contributions of the project team. and the analysis of the costs and benefits of the project. Constructive feedback was provided to the project team, including specific areas for improvement on the job. The development of this project "Smart Solar Hydroponic System Simulation" contributes to society as a promising alternative to generate food resources, using emerging technologies and mechatronic engineering knowledge. The project was developed through effective project planning, management risk management and communication with stakeholders, and the evaluation and feedback process helped ensure the success of the project.

Photovoltaic system, Renewable energy, Hydroponic system, Rainwater capture system, Simulations, Refining, evaluation, Objectives, Analysis, Contributions, Alternative, Virtually, Functionality, Constructive, Development, Promising, Generate, Technologies, Effective

Resumen

El presente proyecto “Simulación de Sistema Hidropónico Solar Inteligente” pretende brindar una posible alternativa de generación de recursos alimentarios que puedan ser consumidos en la comunidad Universitaria y en la localidad de Altamira Tamaulipas. El cronograma del proyecto se dividió en tres etapas, Etapa 1: involucró investigación y capacitación, Etapa 2: seguida de simulaciones y formatos de investigación. etapa 3: consistió en refinar los detalles y planificar la presentación en forma virtual. De esta manera se realizo la evaluación y retroalimentación del proyecto involucró la revisión de los objetivos y metas del proyecto, la prueba de la simulación para asegurar la funcionalidad adecuada, el análisis de la metodología del proyecto, la revisión de las contribuciones del equipo del proyecto y el análisis de los costos y beneficios del proyecto. Se proporcionó retroalimentación constructiva al equipo del proyecto, incluidas áreas específicas de mejora en el trabajo. El desarrollo de este proyecto "Simulación de sistema hidropónico solar inteligente” contribuye a la sociedad como una alternativa prometedora para generar recursos alimentarios, utilizando tecnologías emergentes y conocimientos de ingeniería mecatrónica. El proyecto fue desarrollado a través de la planificación eficaz del proyecto, la gestión de riesgos y la comunicación con las partes interesadas, y el proceso de evaluación y retroalimentación ayudaron a garantizar el éxito del proyecto.

Sistema fotovoltaico, Energía renovable, Sistema hidropónico, Sistema de captación de agua de lluvia, Simulaciones, refinación, Evaluación, Objetivos, Análisis, Aportes, Alternativa, Virtualmente, Funcionalidad, Constructivo, Desarrollo, Promisorio, Generar, Tecnologías, Efectivo

Citation: PONCE-GONZALEZ, Cristopher, ANTONIO-ANTONIO, Alejandrina, MERINO-TREVIÑO, Marco, Antonio and PEÑA-DELGADO, Adrián Fermín. Smart solar hydroponic system simulation. Journal of Systematic Innovation. 2023. 7-21: 7-17

* Correspondence to Author (e-mail: aantonio@utaltamira.edu.mx)
† Researcher contributing as first author.

Introduction

The Smart Solar Hydroponic System Simulation project is an innovative initiative that aims to simulate and evaluate the performance of a solar-powered hydroponic system. Hydroponic systems are becoming increasingly popular as a sustainable alternative to traditional agricultural methods, allowing year-round crop production with minimal water use and space requirements (Small-Scale Aquaponic Food Production. Integrated Fish and Plant Farming, n.d.). In addition, solar energy is a clean and renewable energy source that can significantly reduce operating costs.

The simulation will allow analysis of several factors, including crop growth rates, nutrient supply systems, water use and energy efficiency. The project team plans to use advanced technologies, such as machine learning algorithms, to optimise system performance and predict future crop yields.

The smart solar hydroponic system simulation project has the potential to revolutionise the agricultural industry by providing a sustainable and cost-effective method for producing fresh produce. Furthermore, this project aligns with the global goal of reducing carbon emissions and promoting sustainable development.

Overall, the smart solar hydroponic system simulation project is an exciting venture that has the potential to have a significant impact on the future of agriculture.

Hydroponics is a method of growing plants without soil, using a nutrient-rich water solution. The history of hydroponics dates back to ancient times, when the Hanging Gardens of Babylon were thought to have used a form of hydroponics to grow their plants. However, the modern concept of hydroponics is generally attributed to the work of William Frederick Gericke, a professor at the University of California, Berkeley in the 1920s (From Fertigation *et al*., n.d.).

Overall objective

Design and automate the process using emerging technologies such as IOT communications or artificial intelligence called "Smart Solar Hydroponic System Simulation" to generate a possible alternative to provide food resources that can be consumed by both the University community and the local community (Li *et al*., 2014).

Specific objectives

- To design a hydroponic system and generate food resources that can be consumed by both the school community and the local community.
- Automate the process by using emerging technologies such as IOT communications or artificial intelligence.
- It allows to produce more and with less risk under climatic conditions.
- Raise awareness of the use of hydroponics in society in general.
- It does not require more space.

Justification

The proposed research aims to develop a solar and intelligent hydroponic system in order to optimise food production, reduce costs, promote self-sustainability and raise awareness of the importance of avoiding over-processed food. This innovative approach offers direct benefits to the community by providing more accessible and healthy food, while contributing to long-term environmental sustainability through the use of renewable energy and sustainable agricultural practices. This research seeks to address current challenges in producing food efficiently and responsibly.

Issue

Nowadays society leads such a changing life, where the majority of the population consumes canned, frozen products that over time represent a problem for human health, due to the loss of nutrients and the presence of harmful additives, and have negative effects on the environment, due to their intensive production and the generation of non-biodegradable waste.

It is essential to encourage healthier and more sustainable diets, promoting the intake of fresh and local foods, and reducing dependence on processed foods.

Theoretical framework

Hydroponics is a plant cultivation technique based on the use of aqueous solutions instead of soil to provide the nutrients necessary for plant growth. Plants are grown in an inert medium, such as gravel, sand, rock wool or other inert substrates, in which a nutrient solution containing all the nutrients necessary for plant growth and development is supplied (Benizri *et al.*, 1995).

It is also considered a sustainable and efficient cultivation method, as it allows optimal use of water, nutrients and light, and can be used anywhere, even in urban areas with little space for traditional gardens.

General advantages

Water savings: Hydroponics uses a closed water recirculation system, which means that much less water is required than conventional soil cultivation.

Higher yields and production: hydroponic crops can produce more food per unit area than soil crops.

Nutrient control: In hydroponics you can precisely control the amount and type of nutrients your plants receive, resulting in faster and healthier growth.

Less pesticide use: Because hydroponic crops are grown in a controlled environment, it is possible to significantly reduce the use of pesticides and herbicides.

Year-round production: Hydroponics allows for year-round crop production, regardless of external weather conditions.

Space-saving: Hydroponics is a vertical growing technique that allows plants to be grown in small spaces, which is ideal for production in urban areas and areas with space limitations.

Higher quality food: Food grown in hydroponic systems is of high quality, as the growing conditions are carefully controlled.

Types of hydroponic systems

NFT (Nutrient Film Flow) system

This system uses a thin film of nutrient water that flows over the roots of the plants through inclined channels. The water film is continuously recirculated and can be adjusted to maintain a suitable temperature and pH for the crop. This system is ideal for green leafy plants and herbs.

Aeroponic system

In this system, the roots of the plants are suspended in the air and sprayed with a nebulised nutrient solution. The roots are exposed to the air and there is no contact with solid growing media, which allows for greater oxygen uptake and a higher growth rate. This system is ideal for growing high-density, fast-growing plants.

Drip system

This system consists of a system of pipes and a set of drippers that release the nutrient solution to the roots of the plants. Nutrients are supplied at regular intervals and the remaining solution is collected and recirculated. This system is ideal for plants that require more water and nutrients.

Root immersion system

Also known as a flotation system, this system immerses the roots of the plants in a nutrient solution and keeps them in constant contact with it. Oxygen is supplied to the roots through air bubbles, which maintains a suitable environment for plant growth. This system is ideal for plants that require a high level of moisture at the roots.

Drip irrigation system

This system uses a growing medium such as coconut fibre or perlite to support the plants, which are watered through a system of pipes and drippers. The growing medium helps retain moisture and nutrients, and excess nutrient solution is collected and recirculated. This system is ideal for fruit and vegetable plants.

ISSN 2523-6784

PH

The pH is a measure of the acidity or alkalinity of a solution. It is a scale ranging from 0 to 14, with 7 being neutral. A pH below 7 is acidic, while a pH above 7 is alkaline or basic. pH is an important parameter in many fields, including chemistry, biology, agriculture and environmental sciences, as it can affect the properties and behaviour of living substances and organisms (Domingues *et al*., 2012).

Water is a fundamental resource for life on Earth, and its pH is an important parameter for understanding the chemical and biological processes occurring in aquatic environments. The pH of water is determined by the concentration of hydrogen ions (H+) and hydroxide ions (OH-) present in solution. When water has a pH of 7, it is considered neutral, meaning that the concentration of H+ and OH- ions is equal. When the concentration of H+ ions is greater than the concentration of OH- ions, the water is considered acidic, and when the concentration of OH- ions is greater than the concentration of H+ ions, the water is considered alkaline or basic.

The pH of natural water sources, such as rivers, lakes and groundwater, can vary widely depending on a variety of factors, including the geology of the surrounding area, the presence of dissolved minerals and gases, and human activities. Some natural water sources, such as acid rain and volcanic lakes, can have extremely low pH values, which can have harmful effects on aquatic organisms and their habitats. On the other hand, some alkaline lakes and streams can have high pH values, which can also be detrimental to aquatic life.

In addition, changes in the pH of water can affect the solubility and mobility of chemicals, nutrients and metals. For example, some metals become more toxic at lower pH values, and some nutrients such as phosphorus and nitrogen may be more available for plant growth at higher pH values.

Therefore, monitoring and regulating the pH of water is important to maintain the health and productivity of aquatic ecosystems, as well as to ensure the safety and quality of drinking water. (*Ragany, M., Haggag, M., El-Dakhakhni, W. y Zhao, B. (2023). Meta-Investigación de Sistemas Agrícolas de Ciclo Cerrado Utilizando Minería de Texto. Fronteras En Los Sistemas Alimentarios Sostenibles* , n.d.).

Soil nutrients

Some of the main nutrients that plants absorb from the soil are:

Nitrogen: used for the formation of proteins, enzymes and chlorophyll.

Phosphorus: essential for root growth as well as flower and fruit production.

Potassium: necessary for water regulation in plant cells, as well as for fruit and seed development.

Calcium: important for cell health and root growth.

Magnesium: is a key component of chlorophyll, making it an essential nutrient for photosynthesis.

In addition to nutrients, plants also absorb water and oxygen from the soil. Water is used to transport nutrients and maintain plant structure, while oxygen is essential for plant respiration and energy production. They can also absorb other nutrients and elements necessary for their growth, such as sulphur, iron, zinc and manganese, among others.

Substrate type

Loam soil: This is a type of soil with an intermediate texture between clay and sand, which makes it ideal for a wide variety of crops.

Clay soil: This is a heavy, dense soil that holds water and nutrients very well, but can also be difficult to work and may require improvements to improve its structure. Examples of edible crops that can be grown on clay soil are potatoes, tomatoes, cauliflower, carrots, wheat and barley.

Sandy soil: is a light, easy to work soil type, but tends to have a low capacity to retain water and nutrients. Examples of edible crops that can be planted in sandy soil are beets, lettuce, corn, squash, strawberries and watermelon.

Loamy soil: A soil type with a texture intermediate between clay and sandy soil, which retains water and nutrients well, but can also be easily compacted. Examples of edible crops that can be grown in clay soil are garlic, onions, spinach, chard, melon and grapes.

Calcareous soil: This is a type of soil with a high concentration of calcium carbonate, which can affect the availability of some nutrients to plants. Examples of edible crops that can be grown in calcareous soils are broccoli, cabbage, kale, onions, garlic and carrots.

Saline soil: This is a type of soil that contains high levels of salt, which can affect the growth of some plants and may require special measures to correct it. However, some edible crops that can grow in saline soils are asparagus, alfalfa, melons and beets.

Compatible crops

Some of the most common crops used in hydroponics include lettuce, tomatoes, peppers, strawberries, cucumbers, herbs such as basil and cilantro, among others. These crops are well suited to hydroponic systems because of their relatively small root system and their ability to grow in a controlled environment without soil. In addition, many of these crops are in high market demand and can be produced efficiently and cost-effectively using hydroponic techniques (Güohler *et al*., 1989).

Another factor that makes these crops popular in hydroponics is their fast growth cycle. Hydroponic crops can grow up to 50 % faster than soil crops due to the constant availability of nutrients and water, which allows for higher production in a shorter period of time.

It is important to keep in mind that different crops have different nutritional and environmental requirements, so it is necessary to select the right crops for the hydroponic system used and adjust nutrient levels and other environmental factors accordingly to achieve optimal production (Kumar & Cho, 2014).

Aquaponics is a sustainable farming system that combines aquaculture with hydroponics, creating a mutually beneficial relationship between fish and plants. The benefits of aquaponics go beyond the production of fresh and healthy food.

In this article, we will discuss the general benefits of aquaponics in detail.

Sustainable food production: aquaponics is a closed-loop system that recirculates water and nutrients and requires up to 90 % less water than traditional farming methods. This makes it an environmentally friendly alternative to conventional farming.

Efficient use of space: aquaponics allows vertical farming, making it possible to grow more food in less space. This is particularly useful in urban areas where land is scarce.

No pesticides or chemicals: aquaponics relies on natural processes to control pests and diseases, eliminating the need for harmful chemicals and pesticides. This means that the food produced is free of harmful residues and safe for consumption.

Year-round harvesting: With the right setup, aquaponics allows fresh produce to be harvested all year round, regardless of the season. This provides a constant supply of fresh and healthy food, even during the winter months.

Reduced energy consumption: Compared to traditional cultivation methods, aquaponics requires less energy. This is because the system relies on natural processes such as gravity and does not require heavy machinery or equipment. Diverse range of crops: aquaponics allows the cultivation of a wide range of crops, including fruits, vegetables, herbs and flowers. This provides a varied diet and helps promote biodiversity.

Economic benefits: Aquaponics has the potential to provide economic benefits to farmers, especially in areas where land is expensive. It is also a viable option for small farmers and urban gardeners, who can sell their produce locally.

ISSN 2523-6784

Educational and therapeutic benefits: Aquaponics is an excellent educational tool that provides hands-on learning opportunities for children and adults alike. It can also have therapeutic benefits, as it is a calming and relaxing activity.

The nitrogen cycle

The nitrogen cycle is a natural process that occurs in nature, is essential for the life of plants and animals, and is of utmost importance in aquaponics. This process takes place in four main stages: nitrification, denitrification, nitrogen fixation and mineralisation.

Nitrification is the first stage of the nitrogen cycle, in which bacteria convert ammonium (NH4+) into nitrite (NO2-) and then into nitrate (NO3-). In aquaponics, this stage occurs thanks to the nitrifying bacteria found in the filters and in the growing medium of the plants.

Denitrification is the second stage of the nitrogen cycle, in which bacteria convert nitrates (NO3-) into nitrogen gas (N2) and nitrous oxide (N2O). In aquaponics, this stage occurs in the root zone of the plants, where anaerobic bacteria reduce the nitrates present in the water.

Nitrogen fixation is the third stage of the nitrogen cycle, where bacteria convert gaseous nitrogen (N2) into ammonium (NH4+). In aquaponics, this stage can occur thanks to the presence of nitrogen-fixing bacteria in the roots of the plants.

Mineralisation is the fourth stage of the nitrogen cycle, in which bacteria break down organic debris and release ammonium (NH4+) into the environment. In aquaponics, this stage occurs through the decomposition of fish and plant waste.

In aquaponics, the nitrogen cycle is essential to maintain a healthy environment for fish and plants. The presence of nitrifying and nitrogen-fixing bacteria is essential for maintaining water quality and supplying nutrients to plants. In addition, the removal of ammonium and nitrite is essential to prevent the build-up of toxic substances in the water and to maintain a healthy environment for the fish.

Types of fish suitable for aquaponics

The selection of appropriate fish species is crucial for a successful aquaponic system (Grozea, 2011). In this article, we will discuss in detail the types of fish that are suitable for aquaponics.

Tilapia: Tilapia is one of the most widely used fish in aquaponics due to its resilience, rapid growth and high tolerance to poor water quality. Tilapia can tolerate a wide range of temperatures, making it suitable for both warm and cold climates.

Catfish: Catfish are another popular choice for aquaponics. They are known for their rapid growth rate and can thrive in a wide range of water temperatures. Catfish are also resistant to many diseases and can tolerate low levels of dissolved oxygen.

Trout: Trout are a cold-water fish that thrive in temperatures between 10°C and 20°C. They require high levels of dissolved oxygen and a stable pH to thrive. Trout can grow rapidly and reach maturity in as little as 12 to 18 months.

Koi: Koi is an ornamental fish species that can add aesthetic value to an aquaponic system. They are hardy and can tolerate a wide range of water temperatures. Koi also produce a significant amount of waste, making them an excellent choice for larger systems.

Barramundi: Barramundi are tropical fish that grow well in warm water. They are known for their sweet and delicate taste, making them a popular choice for aquaponics looking to sell their fish as a premium product. Barramundi require high quality water with a stable pH and high levels of dissolved oxygen.

Bluegill: Bluegill are a popular choice for smaller aquaponic systems. They are hardy and easy to care for, which makes them an excellent choice for beginners also have a high reproductive rate, which means they can quickly establish a breeding population in a small system.

Maintenance and care of the aquaponic system

Maintenance and care are essential for the proper functioning and sustainability of an aquaponic system. Proper maintenance and care can lead to increased production of both fish and plants. Here are some important aspects of maintenance and care of an aquaponic system:

Water quality: The quality of the water in the system should be monitored regularly. Test kits are available to test the water quality for pH, ammonia, nitrate, nitrite and dissolved oxygen. If any of these parameters are outside the acceptable range, steps should be taken to correct them.

Fish health: Fish are an integral part of an aquaponic system and their health should be monitored regularly. Proper nutrition, water quality and temperature must be maintained to keep the fish healthy.

Plant health: Plants depend on nutrient-rich water from fish waste. It is important to check for nutrient deficiencies or toxicity in plants. Any unhealthy plants should be removed immediately to prevent the spread of disease.

System components: All system components, such as pumps, filters and culture beds, should be checked regularly to ensure that they are functioning properly. Any defective components should be replaced or repaired immediately.

Harvesting: Proper harvesting techniques should be used to avoid damage to plants or fish. Fish should be harvested in a humane manner and plants should be harvested at the correct time to obtain the maximum yield.

Cleaning: The system should be cleaned periodically to remove any debris or algae build-up. It is also important to remove any dead plant material or uneaten fish feed from the system.

Pest and disease control: Any signs of pests or disease should be addressed immediately to prevent the spread of infection. Natural remedies or biological controls can be used to address these problems.

Solar panels

Solar energy is a renewable and sustainable energy source that has become an attractive alternative for electricity generation worldwide. Solar panels are an essential component of solar energy systems, as they are responsible for converting sunlight into usable electrical energy.

Solar panels are made up of solar cells, which contain semiconductor materials that absorb sunlight and convert it into electrical energy. Solar panels can be used to power a wide variety of devices, from small solar lights to large-scale solar energy systems to power homes and buildings (Wang *et al*., 2023).

There are different types of solar panels, each with its own advantages and disadvantages. The most common solar panels are photovoltaic (PV) solar panels, which use solar cells to convert sunlight into electrical energy. Solar thermal panels, on the other hand, use solar energy to heat water or air, which can be used to heat buildings or provide hot water.

In addition, there are also hybrid solar panels, which combine photovoltaic and thermal solar panel technologies to maximise energy efficiency and reduce production costs. Hybrid solar panels are particularly useful in areas where sunlight is limited, as they can provide both electricity and heat.

Solar panels are an essential technology for solar power generation and are used in a wide variety of applications, from small devices to large-scale solar power systems. There are different types of solar panels, each with its own advantages and disadvantages, and choosing the right solar panel depends on the specific application.

Methodology

Define project goals and objectives

The project aims to provide an alternative solution to food resources that can be consumed by both the school community and the local community. Specific objectives include making the project economically profitable, automating the process through emerging technologies such as IoT or AI, generating food resources and applying the knowledge acquired during the mechatronics engineering degree (Hinojosa *et al*., n.d.).

Determine the scope of the project

The project will focus on providing a simulation guide for a smart solar hydroponic system that could be of interest to investors, government departments and students studying the topic.

Establish a project team and determine the necessary resources

A laptop with a Core i7 processor and an Nvidia 3070 graphics card will be required for the simulation, and other resources will be provided by the team members' own computers.

Figure 1 Computer equipment for project development

Develop a timetable

The project will be completed in three stages. February-March will be devoted to research and training, March-April will focus on completing simulations and research formats, and April-Final will refine details and plan the presentation.

Identify risks and contingencies

Risks and contingencies, such as technical risks, cost overruns, delays, stakeholder expectations and regulatory compliance, will be addressed through effective project planning, risk management and communication with stakeholders.

Evaluate and provide feedback

The project will be evaluated based on objectives, deliverables, methodology, schedule, project team, costs and benefits. Comments will be constructive and include specific areas for improvement and praise for the team's work. By following this methodology, the project "Simulation of smart solar hydroponic system" can be completed effectively and efficiently, ensuring a successful outcome.

The 5 steps

Planning phase (early February 2023): in this phase, the project team would define the objectives, scope, required resources and timeline of the project. They would also identify potential risks and contingencies and develop a risk management plan. During this phase, the team would determine the specific tasks, activities and deliverables needed to successfully complete the project.

Figure 2 Side view of project simulation

Design phase (mid-February to early March 2023): in this phase, the project team would create the initial design of the simulation, including the system architecture, simulation models and simulation parameters. They would also develop a test plan to ensure that the simulation works as intended. The team would collaborate to ensure that the simulation design meets the project objectives and requirements.

Figure 3 Top view of project simulation

Development phase (mid-March to early April 2023): in this phase, the project team would implement the design, develop and integrate the simulation models, and test the simulation to ensure that it meets the requirements. They would also address any technical issues that arise during development and testing.

Testing phase (mid to late April 2023): in this phase, the team would conduct extensive testing of the simulation to ensure that it works correctly and generates accurate results. The team would use the test plan developed in the design phase to identify and address any defects or problems.

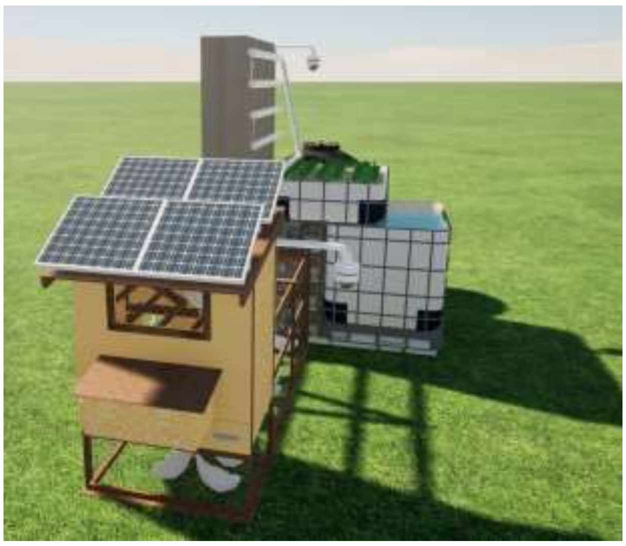

Figure 4 Front view of project simulation

Implementation phase (end of April 2023): in this phase, the project team would implement the simulation for its intended audience. They would also provide training and documentation to users to ensure that they understand how to use the simulation effectively. The team would conduct a final review to ensure that the simulation meets the goals and objectives of the project.

Results

As a result, the design and simulation of a solar and intelligent hydroponic system that allows the self-sustainable production of healthy food for the population of Tamaulipas is shown, thus guaranteeing greater reliability and profitability for the proper functioning of the project, the estimated cost for the development of the project will be $14,865.00.

Finally, illustration 5 shows the completed project.

Technological University of Altamira Project cost table ***Hydroponic system simulation Solar and intelligent***			
Quantity	Description	Price	Amount
1	Tinaco Rotoplas	$3,733.00	$3,733.00
1	450 lts	$6,290.00	$6,290.00
1	IBC 1000 L container	$1,953.00	$1,953.00
1	Kit of 18W solar panels and 4000 w power inverter	$498.00	$498.00
1	Submersible water pump of 12v ½ inch 24w	$988.00	$988.00
1	Dry Clay Stones for hydroponics	$312.00	$312.00
1	Durable hydroponic pots	$237.00	$237.00
7	Biochemical plastic filter units for hydroponics aquaculture	$122	$854.00
Total			$14,865.00

Table 1 Project Cost Table

Figure 5 Project Simulation

Acknowledgements

We would like to thank Mr. Cristóbal Ponce Alvarado for the facilities of the land for the development of the project and the student Gabriel Antonio Martínez Duque for his donation of poultry for the development of the experimental phase of the project.

Conclusions

In conclusion, a project to simulate an intelligent solar hydroponic system has great potential to revolutionise agriculture and make it more sustainable. By using a combination of solar energy, hydroponic technology and intelligent control systems, this system can optimise plant growth and resource utilisation while reducing environmental impact and operating costs.

The simulation model developed in this project can help identify optimal configurations for different crop types and growing conditions, as well as predict their performance under various scenarios. This can help farmers and investors make informed decisions about which crops to grow, where to grow them and how to manage resources effectively.

In addition, the integration of smart technologies such as sensors, IoT and machine learning algorithms can enable real-time monitoring and data analysis of key parameters such as temperature, humidity, pH and nutrient levels. This can enable precise control of the growing environment, ensuring optimal conditions for plant growth and avoiding waste of resources.

In addition to the economic benefits, the implementation of this system can have positive environmental impacts, such as reducing water use and reducing the carbon footprint associated with traditional agriculture. This is particularly relevant in regions with limited water resources and where traditional agricultural practices have led to soil degradation and other environmental problems.

Overall, a smart solar hydroponic system simulation project can contribute to the transition towards a more sustainable and resilient agricultural sector. However, further research and development is needed to fully exploit its potential and overcome technical and economic barriers.

Funding

This work has been funded by the Technological University of Altamira.

References

Benizri, E., Courtade, A., & Guckert, A. (1995). FATE OF TWO MICROORGANISMS IN MAIZE SIMULATED RHIZOSPHERE UNDER HYDROPONIC AND STERILE CONDITIONS. In *Soil Viol. Eiochem* (Vol. 27, Issue I).

De Fertirrigación, E., De, C., Automáticos, F., Rotativos, Y., & Accesorios, E. Y. (n.d.). *LINEA DE PRODUCTOS PARA CULTIVOS SIN SUELO*.

Domingues, D. S., Takahashi, H. W., Camara, C. A. P., & Nixdorf, S. L. (2012). Automated system developed to control pH and concentration of nutrient solution evaluated in hydroponic lettuce production. *Computers and Electronics in Agriculture*, *84*, 53–61. https://doi.org/10.1016/J.COMPAG.2012.02.006

Grozea, A. (2011). *Increasing the Economical Efficiency and Sustainability of Indoor Fish Farming by Means of Aquaponics-Review Out-of-season reproduction in sterlet (Acipenser ruthenus) View project*. https://www.researchgate.net/publication/228442364

Güohler, F., HeiÎ²ner, A., & Schmeil, H. (1989). CONTROL OF WATER AND NUTRIENT SUPPLY IN GREENHOUSE VEGETABLE PRODUCTION BY MEANS OF HYDROPONIC SYSTEMS. *Acta Horticulturae*, *260*, 237–254. https://doi.org/10.17660/ACTAHORTIC.1989.260.13

Hinojosa, S., Autor, P., & Pinto, S. H. (n.d.). *Diseño de una arquitectura IoT para el control de sistemas hidropónicos MEMORIA PRESENTADA POR.*

Kumar, R. R., & Cho, J. Y. (2014). Reuse of hydroponic waste solution. *Environmental Science and Pollution Research*, *21*(16), 9569–9577. https://doi.org/10.1007/S11356-014-3024-3

Li, M., Ishiguro, Y., Otsubo, K., Suzuki, H., Tsuji, T., Miyake, N., Nagai, H., Suga, H., & Kageyama, K. (2014). Monitoring by real-time PCR of three water-borne zoosporic Pythium species in potted flower and tomato greenhouses under hydroponic culture systems. *European Journal of Plant Pathology*, *140*(2), 229–242. https://doi.org/10.1007/S10658-014-0456-Z

Ragany, M., Haggag, M., El-Dakhakhni, W. y Zhao, B. (2023). Meta-investigación de sistemas agrícolas de ciclo cerrado utilizando minería de texto. Fronteras en los sistemas alimentarios sostenibles. (n.d.).

Small-scale aquaponic food production. Integrated fish and plant farming. (n.d.).

Wang, T., Chen, K., Hu, X., Liu, P., Huang, Z., & Li, H. (2023). Research on coordinated control strategy of photovoltaic energy storage system. *Energy Reports*, *9*, 224–233. https://doi.org/10.1016/J.EGYR.2023.04.293