2024-2025

Capstone portfolio

Greenhouse Soil and Irrigation Monitoring System

Group 22321
Semester 1
Grade 12

TABLE OF CONTENTS

2025-1-22321

Egypt's grand challenges:

1-Improve the use of alternative energy.

2-Recycle garbage and waste for economic and environmental purposes.

3-Deal with urban congestion and its consequences.

4-work to eradicate public health issues/diseases.

5-Increase the industrial and agricultural basis of Egypt.

6-Adderss and reduces pollution following out air, water, and soil.

7-Improve uses of arid areas.

8-Manage and increase the sources of clean water.

9-Deal with population growth and its consequences.

10-Improve the scientific and technological environment of all.

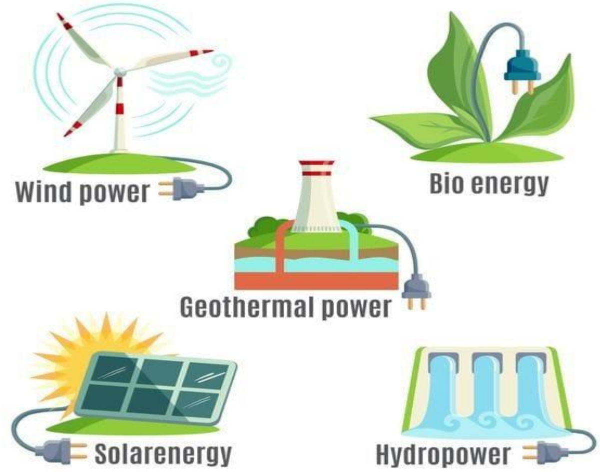
11-reduce and adapt to the effect of climate change.

Present and Justify a Problem and Solution Requirements

➢ Egypt Grand Challenge

❖ *Improve the use of alternative energies*

What is alternative energy?
Alternative energy comes from sources other than the traditional fossil fuels of oil, coal, and natural gas. It includes renewable sources such as solar, wind, geothermal, hydropower, and biomass, these energy sources are plentiful and all around us. It also includes non-renewable sources such as nuclear power.



Generating renewable energy produces far fewer emissions than burning fossil fuels.
Fossil fuels, when burned to produce energy, cause harmful emissions of greenhouse gases, such as carbon dioxide.

Renewables are cheaper in countries and generate three times more jobs than fossil fuels.

What is the importance of using alternative energy?
The importance of using alternative energy in the world cannot be overstated. The burning of fossil fuels is a major contributor to climate change and air pollution. By transitioning to alternative energy sources, we can reduce our dependence on fossil fuels and help mitigate the effects of climate change. Additionally, many alternative energy sources are renewable and can provide a more reliable source of energy than fossil fuels.

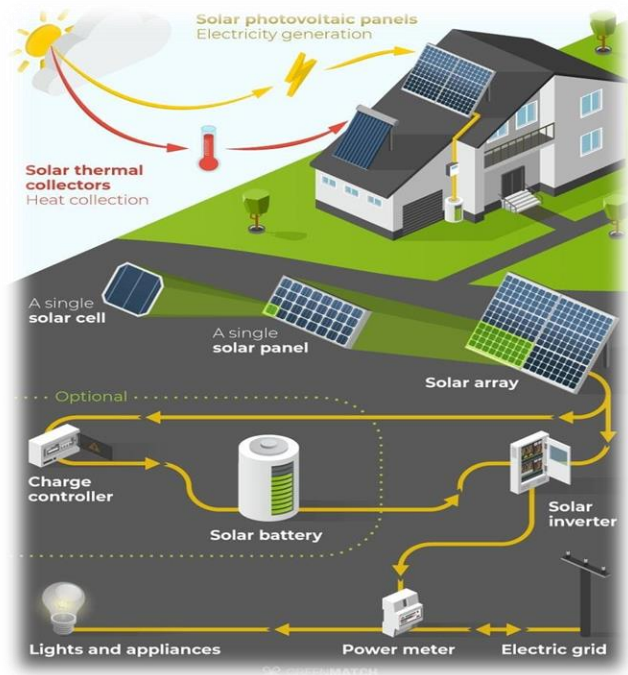
In addition to environmental benefits, using alternative energy can also have economic benefits. Renewable energy sources are often cheaper than traditional fossil fuels in the end because they do not require costly extraction or refining processes. This can help reduce costs for consumers and businesses alike. Furthermore, investing in renewable energy can create jobs in industries such as solar panel installation or wind turbine maintenance. This can help stimulate local economies and create more opportunities for people to find employment.

Finally, using alternative energy can help increase global security by reducing our dependence on foreign oil supplies. By relying more on domestic renewable resources such as solar or wind power, we can reduce our reliance on foreign suppliers who may not always have our best interests in mind. This could potentially lead to greater stability in global markets and improved relations between countries that rely heavily on imported oil supplies.

Overall, improving the use of alternative energy is essential for a sustainable future for our planet and its inhabitants. It has numerous environmental, economic, and security benefits that make it an attractive option for countries around the world looking to transition away from traditional fossil fuels toward cleaner forms of energy production.

Examples of alternative energy:

1-Solar Energy



Solar energy is Radiation from the Sun capable of producing heat, causing chemical reactions, or generating electricity. The total amount of solar energy incident on Earth is vastly in excess of the world's current and anticipated energy requirements.

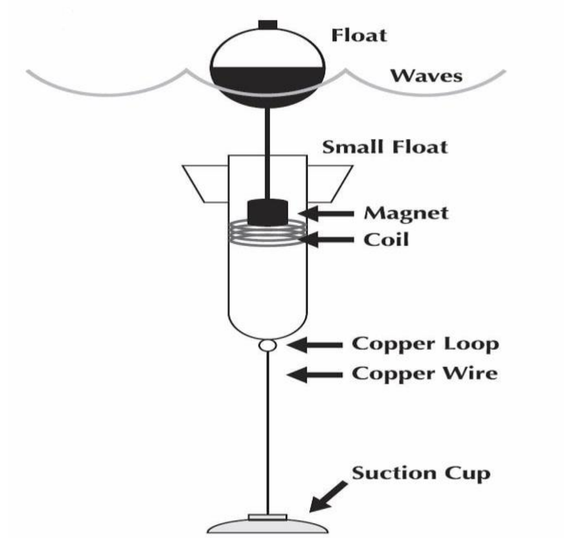
The United States contains among of the world's most prolific and cleanest solar resource bases. Solar energy is the most abundant and clean renewable energy source currently available. Solar technology can capture this energy for a range of purposes, such as electricity generation, interior lighting, and water heating for household, commercial, and industrial use.

The potential for solar energy is enormous since about 200,000 times the world's total daily electric-generating capacity is received by Earth every day in the form of solar energy. Unfortunately, though solar energy itself is free, the high cost of its collection, conversion, and storage still limits its exploitation in many places. Solar radiation can be converted either into thermal energy (heat) or into electrical energy.

2- Wind Energy

Wind energy harnesses the kinetic energy of moving air by using large wind turbines located on land (onshore) or in the sea- or freshwater (offshore). The technology of windmills used to harness the power of wind has advanced significantly over the past ten years, with the United States increasing its wind power capacity by 30% year over year. Wind energy is a byproduct of the sun. The sun's uneven heating of the atmosphere, the earth's irregular surfaces (mountains and valleys), and the planet's revolution around the sun all combine to create wind. As the wind is always available, it is a resource that may be used indefinitely as long as the sun continues to heat the earth.

3-Wave power



Waves form as wind blows over the surface of open water in oceans and lakes. Ocean waves contain tremendous energy. Wave power is generated from the conversion of the kinetic energy associated with the rise and fall of ocean waves into electrical energy via a range of capture and conversion technologies, including hydraulic rams, pumps, and turbine technologies. Wave energy (or wave power) is the transport and capture of energy by ocean surface waves. The energy captured is then used for all different kinds of useful work, including electricity generation, water desalination, and pumping of water. There are undoubtedly challenges to harnessing this renewable energy. Building and operating wave energy plants are generally expensive. Cables, turbines, and other infrastructure could potentially harm marine life. In addition, because the plants rely on coastal locations, they may not be able to support whole populations.

❖ ***Recycled garbage and wastes for economic and environmental purposes.***

Recycling is the process of converting waste materials into reusable resources or new products, thereby reducing the consumption of raw materials and the generation of waste. It is an essential component of sustainable waste management and plays a critical role in conserving natural resources, minimizing pollution, and mitigating the environmental impact of human activities.

It is important for individuals, businesses, and governments to actively participate in recycling efforts. By implementing effective recycling programs, raising awareness, providing incentives, and supporting sustainable practices, we can maximize the economic and environmental benefits of recycling and contribute to a more sustainable future by following the standard steps of recycling which are explained below.

- **Steps of recycling :**

1- Collection: The first step is the collection of recyclable materials.

2- Sorting: Once collected, the recyclable materials are sorted based on their material type. This step involves separating different types of materials, such as paper, plastic, glass, metal, or electronic waste.

3- Processing: After sorting, the materials undergo processing to prepare them for reuse. This step varies depending on the material type.

4- Manufacturing: The processed materials are used as raw materials in the manufacturing of new products. The recycled materials are combined with other additives or virgin materials as needed to create new products.
5- Distribution and Consumption: The newly manufactured products made from recycled materials are distributed to consumers and used in households, businesses, and industries.

It is important for individuals, businesses, and governments to actively participate in recycling efforts. By implementing effective recycling programs, raising awareness, providing incentives, and supporting sustainable practices, we can maximize the economic and environmental benefits of recycling and contribute to a more sustainable future as recycling garbage and waste for economic and environmental purposes offers numerous benefits.

❖ *Increase the industrial and agricultural bases of Egypt.*

Clutters- the geographic concentration of specialized firms that are working in similar or related activities and are interdependent have played an important role in the industrial development of many countries. A large part of these successes can be explained by the ability of clusters to build on existing strengths of local communities such as social capital and abundant labor to overcome common constraints to economic expansion such as weak financial markets and institutions. Realizing the potential for cluster-based development and the long history of clusters in the country, the Egyptian government has made cluster-based sterilization a key pillar of Egypt's sustainable development strategy for 2030. The timing for a cluster-based industrial development model for Egypt seems favorable as macroeconomic reforms in recent years have made Egypt's economy more competitive and the country's young labor force provides a comparative advantage for labor-intensives. Our findings suggest focusing cluster development efforts on Upper Egypt. In order to complement the ongoing macroeconomic and safety net reforms in Egypt, it is important to foster additional sector-specific economic growth, especially in sectors that are good at creating jobs and reducing poverty. One sector that may help foster socio-economic development in the coming years is agriculture and related agro-processing industries.

Effects and importance of increasing industrial and agricultural bases in Egypt

- Greatly expand output.
- To provide employment and adequate living conditions for a naturally growing population.
- To market what industry and agriculture create, either domestically or overseas.

❖ *Improve the scientific and technological environment.*

The developed world is heavily reliant on technology which makes life much easier and production much more efficient. Technology is lacking in developing countries and this contributes to widespread poverty and a lack of basic amenities such as clean, running water and food supplies. This ensures that solving this Egyptian grand challenge and Improving the scientific and technological environment for all – is necessary that is needed for Egypt's development and a new vision for the future. Addressing this challenge will make the efficiency and the quality of many products higher also it will show the abilities of the country and its status among countries.

❖ *Reduce and adapt to the effect of climatic change.*

Climate change is one of the most important challenges to address due to its wide-ranging and profound impacts on the planet and human society. The Earth's climate is changing at an unprecedented rate primarily due to human activities, such as burning fossil fuels and deforestation, leading to increased greenhouse gas concentrations and global warming. The consequences of climate change include rising temperatures, sea-level rise, extreme weather events, loss of biodiversity, disruptions to ecosystems, and threats to food and water security. Addressing climate change is crucial to protect the environment, preserve natural resources, safeguard human health, promote sustainability, and ensure a livable planet for future generations.

• The variables that influence the climate change:

1- Burning garbage produces high temperatures and air pollution.
2- Taking down trees aids in the removal of carbon dioxide.
3- Burning fossil fuels three.
4- Expansion of the use of non-renewable energy.
5- The pace at which solar radiation strikes the planet.
6- Pollution of the water, air, and land.
7- Electric generators and automobile exhaust.
8- Nitrogen-containing fertilizers.

• The importance of reducing adapting to the effect of climatic change:

Climate change is a pressing issue that requires immediate and proactive action to preserve the environment, human security, food and water security, economic stability, and social justice. It is causing irreversible damage to ecosystems and natural resources, threatening biodiversity and maintaining the planet's ecological balance. Adapting to climate change is crucial to protect communities from extreme weather events, ensuring safety and security.

Agricultural productivity and water availability are being disrupted by climate change, posing a threat to global food and water security. Adapting agricultural practices, promoting sustainable farming techniques, and investing in water management systems can enhance resilience and ensure food security, alleviate hunger, and provide clean water access for vulnerable populations.

Climate change has profound economic implications, fostering innovation, creating new job opportunities, and stimulating economic growth in the renewable energy sector. Resilient infrastructure development and disaster risk reduction measures can reduce economic losses associated with extreme weather events, ensuring long-term economic stability.

Addressing climate change requires a just and equitable approach, prioritizing the needs of marginalized groups, providing access to resources and opportunities, and promoting inclusive policies. By taking immediate and proactive measures, individuals, governments, and organizations can build a sustainable and resilient future for generations to come.
Reducing greenhouse gas emissions and adapting to the effects of climate change are vital for environmental preservation, human security, food and water security, economic stability, and social justice. It is incumbent upon individuals, governments, and organizations to take immediate and proactive measures to address climate change and build a sustainable and resilient future for generations to come.

➢ Problem to be solved

This solution addresses five Egyptian grand challenges and solving them to improve of Egyptian state, these challenges are Improving the use of alternative energies, recycling garbage and waste for economic and environmental purposes, improving the scientific and technological environment for all, reducing the adapt to the effect of climate change and increasing the industrial and agricultural base of Egypt.

❖ Improve the use of alternative energies

The major positive points of recycling if it is done:

1- A fuel supply that never runs out.
2- Zero carbon emissions.
3- Clean air and water.
4- A cheaper form of electricity.
5- Renewable energy creates new jobs.

The major negative points -if recycling is not done:

1- Higher capital costs.

2- Electricity production can be unreliable

3- Energy storage is a challenge.

4- Environmental conditions affect it.

5- Renewables still have a carbon footprint.

❖ Recycled garbage and wastes for economic and environmental purposes.

The major positive points of recycling if it is done:

1- Reduce pollution
2- Circular economic instead of linear economic
3- Energy savings and reduced emissions
4- Conservation of natural resources
5- Job Creation: Recycling and waste management industries create employment opportunities in the collection, sorting, processing, and manufacturing sectors.
6- Cost savings
7- Waste Reduction
8- Environmental protection
9- Reduces the Need for Landfill Expansion

The major negative points -if recycling is not done:

1- Negative health impacts
2- Missed opportunities for innovation
3- Reduced environmental awareness and education
4- Limited Availability of Recycled Products
5- Loss of Economic Opportunities
6- Pollution and Environmental Degradation
7- Energy Intensity and Greenhouse Gas Emissions
8- Depletion of Natural Resources
9- Increased Waste Generation

These negative points underscore the importance of recycling as a crucial component of sustainable waste management. By not recycling or neglecting recycling efforts, we risk adverse environmental, economic, and social impacts.

❖ Increase the industrial and agricultural bases of Egypt.

The positive impacts

- Making things easier for young entrepreneurs who may not have the capital to purchase their facilities.
- The governorates of southern Egypt will have great potential for investment in the industrial and export sectors, and the government is working to grant industrial lands to investors for free.
- The cost of production will be cheaper in Egypt's new cities, and continued investment in them encourages the workforce to reside in the new cities and contribute to their development and growth.
- It creates direct job opportunities for young people, reduces unemployment rates, makes new products available to the Egyptian market, reduces imports, and eases pressure on hard currency needs.
- Reducing pressure on the environment.
- Raising farm productivity leads to income growth in agriculture.

The negative impacts

- Declining share of agriculture in economic output and employment.
- Increasing share of urban economic activity in modern industry and services.
- Migration of rural workers to urban areas, and a demographic shift in birth and death rates that always leads to a surge in population growth before reaching a new equilibrium.
- Consumer demand may steadily evaporate, and natural resources may be depleted.
- There may be emerging substitutes due to technological innovation.

❖ Improve the scientific and technological environment.

Solving this challenge will provide a higher technologized environment for all people with different categories also it will make the percentage of technological industries higher. Not solving this challenge has many consequences like putting the country at the risk of not moving forward and stopping the moving forward through the future that the country aims to achieve.

❖ Reduce and adapt to the effect of climatic change.

The major positive effects if problem of the climate change is solved:

Climate change has the potential to have significant positive outcomes for various sectors. It can mitigate the devastating impacts on the environment, such as preserving ecosystems and protecting biodiversity. By promoting clean energy sources and sustainable transportation systems, we can improve air quality and reduce respiratory illnesses. Mitigating extreme

weather events can lower the risks of injuries, diseases, and mental health issues.
The economic benefits of climate change are significant, as transitioning to renewable energy sources and adopting sustainable practices can stimulate job creation and economic growth. Investments in clean technologies and infrastructure can lead to innovation, increased productivity, and enhanced competitiveness in the global market.
Moreover, reducing the effects of climate change can promote social equity and justice, benefiting vulnerable communities by improving resilience, access to clean energy, and enhanced livelihood opportunities. This can lead to a healthier planet, improved well-being, sustainable economic development, and a fairer society. Taking decisive action to address climate change is crucial for securing a better future for all.

The major negative effects if problem of the climate change is not solved:

Failure to solve the problem of climate change would result in severe consequences across various domains. Increased global temperatures would lead to more frequent and intense extreme weather events, causing extensive damage, displacement of communities, and loss of lives. Ecosystems and biodiversity would suffer, with disrupted habitats and increased risk of species extinction. Food and water security would be compromised as changing weather patterns and reduced agricultural productivity result in crop failures, food shortages, and water scarcity. Public health would be at risk due to heat-related illnesses, the spread of diseases, and heightened air pollution.

Economically, the costs of climate change would be substantial. Infrastructure damage, increased insurance premiums, and disruptions to supply chains would lead to significant financial losses. Rebuilding and recovering from climate-related disasters would strain economies, particularly in developing nations. Socially, there would likely be increased social unrest and geopolitical tensions as competition for resources intensifies. Climate refugees and mass migrations could exacerbate existing conflicts and create humanitarian crises.

To avoid these dire consequences, urgent action to address climate change is imperative. This includes reducing greenhouse gas emissions, transitioning to sustainable energy sources, implementing resilient infrastructure, and adopting sustainable agricultural practices. International cooperation and commitment are essential to effectively tackle this global challenge and secure a sustainable future for generations to come.

➢ Research

Building an integrated multi-sensor system designed for a greenhouse environment in Egypt, aimed at effectively monitoring soil and plant conditions and leveraging renewable energy and eco-friendly materials offers an approach to mitigating climate change impacts and enhancing environmental sustainability which is one of the countries' concerns now. This will done by recycling garbage and waste for economic and environmental purposes. The government is working on several number of projects to improve the scientific and technological environment for all. According to these challenges, we searched the topics related to the problems and the solutions which will help in a deeper understanding of the problem and how to solve it.

The topics which we researched about the problems:

- Alternative Energies for usage
- Reduce the effect of climate change.
- The technological environments.
- Recycle garbage and waste.
- Increase Industrial bases and agriculture in Egypt

The topics which we researched about the solutions:

- Prior solutions about the greenhouses in the world.
- What is the feedback system?
- The components of the Arduino board and its connections.
- Types of sensors and their usage.
- The connection between IOT and Arduino system.

➢ Other Solutions Already Tried

Design and Implementation of Soil Moisture Monitoring and Irrigation System based on ARM and IoT

The proposed framework for soil humidity control and watering management utilizes the Internet of Things (IoT) and ARM technology, specifically through a Raspberry Pi. This system automates irrigation processes by collecting data from humidity, temperature, and sound sensors, which are then transmitted to a cloud server. A web application provides users with access to this data, enabling informed decision-making about irrigation.

Advantages:

1. **Cost Reduction**: The automated system minimizes the need for manual labor and reduces operational costs associated with traditional irrigation methods.
2. **Water Efficiency**: By optimizing irrigation based on real-time soil conditions, the framework significantly reduces water waste, promoting sustainable water usage.
3. **Low Maintenance**: The system's design aims for low maintenance requirements, reducing the need for frequent human intervention.
4. **Environmental Sustainability**: By minimizing physical interference and promoting efficient water usage, the framework supports environmentally friendly agricultural practices.

5. **Data Accessibility**: The integration with a cloud server allows for easy access to valuable data through a web application, facilitating timely decision-making.
6. **Automated Alerts**: The system can send email notifications when conditions trigger irrigation, ensuring timely responses to changing environmental factors.

Disadvantages:

1. **Initial Setup Costs**: The initial investment in sensors, Raspberry Pi, and cloud infrastructure may be high, potentially deterring smaller farmers.
2. **Technical Complexity**: Users may require a certain level of technical understanding to operate and maintain the system effectively, which could limit adoption among less tech-savvy individuals.
3. **Dependency on Internet Connectivity**: The system relies on stable Internet access for cloud communication, which may pose challenges in remote or rural areas with poor connectivity.
4. **Sensor Limitations**: The accuracy of the system depends on the quality and calibration of sensors. Malfunctioning sensors could lead to incorrect data and ineffective irrigation.
5. **Scalability Concerns**: As the system is designed for specific conditions, scaling it for larger or varied agricultural environments may require additional adjustments or resources.

Towards automated greenhouse

Greenhouses, as controlled environments, consume fewer resources and emit less greenhouse gas than traditional field production. Intelligent monitoring systems enhance energy savings, predict extreme conditions, reduce pests and diseases, and minimize pesticide use, leading to higher-quality food. Despite growing interest in these systems, effective implementation remains a challenge. This paper systematically reviews greenhouse monitoring technologies, detailing data transmission and server processing subsystems while identifying key environmental parameters. It highlights the trend toward multi-parameter monitoring and wireless data transmission, emphasizing the potential of advanced technologies like deep learning and big data to improve energy utilization and facilitate unmanned greenhouse management.

Advantages:

1. **Enhanced Crop Growth**: Automated systems can significantly increase crop growth rates, such as doubling tomato yields.
2. **Resource Efficiency**: Reduces energy consumption by 25% and water usage by 33%, optimizing resource utilization.

3. **Improved Environmental Control**: Continuous monitoring leads to better quality and yield by maintaining optimal conditions.
4. **Reduction in Pesticide Use**: Controlled environments decrease the need for chemical pesticides by managing pests and diseases effectively.

Disadvantages:

1. **Complexity of Implementation**: Designing and implementing these systems can be challenging and complex.
2. **Initial Costs**: High upfront costs for technology and installation may deter some producers.
3. **Limited Practical Application**: Many systems are still in the research phase and not widely adopted in production.
4. **Dependence on Technology**: Reliance on technology poses risks if systems fail or lack adequate support.

Light Intensity and machine interface environmental control of a greenhouse system:

This project presents a solution for regulating light intensity in a greenhouse system using a human-machine interface (HMI). The system is designed to support plant growth, particularly in sunless environments, by utilizing light-emitting diodes (LEDs). A prototype greenhouse is equipped with sensors like the light-dependent resistor (LDR) to measure light intensity. By controlling the combination of red and blue LEDs, the system provides the appropriate light for plant growth, focusing on basil in this case. The project integrates an Arduino Uno microcontroller, Bluetooth module, and a smartphone app developed with MIT App Inventor 2 to adjust light intensity remotely.

Advantages:

- Cost-efficient: The system uses affordable components like LEDs and Arduino, making it accessible for small-scale applications.
- Energy-efficient: LEDs consume less power compared to traditional lighting systems.
- Remote control: The system can be conveniently controlled via a smartphone, enhancing flexibility.
- Customizable: Light intensity can be adjusted according to plant needs, promoting healthier growth in low-light environments.

Disadvantages:

- Limited scope: The project primarily focuses on light intensity, while other important factors like humidity and temperature are not fully automated.

- Manual calibration: Light intensity measurements using a lux meter are manual, which may reduce efficiency.

Generating and Defending a Solution

➢ Solution and Design Requirements

In any project, there are two types of design requirements, general solution requirements, and project-specific design requirements.

Solution Requirements

These are the design requirements that must be available in any project to ensure the efficiency and usability of the project, and they are summarized in:
- Effectiveness: The solution must address the problem statement and achieve the desired outcomes, meeting the project objectives and requirements.
- Efficiency: The solution should optimize the use of resources, time, and effort, ensuring that the project is completed within the allocated constraints, minimizing waste, and maximizing output.
- Reliability: The solution should consistently deliver accurate and dependable results, demonstrating its ability to perform consistently over time.
- Scalability: The solution should be designed to accommodate future growth or expansion, allowing for potential modifications or enhancements.
- Maintainability: The solution should be easy to maintain and update to ensure long-term functionality.

By incorporating these characteristics, a solution can be deemed successful as it effectively solves the problem, maximizes efficiency, delivers reliable results, adapts to growth, and is easily maintained for future use.

Design Requirements

To deal with the chosen solution, there are eight design requirements were chosen to achieve the desired results and to make the solution successful.

-The first design requirement involved using Multi-Sensor Integration.

-The second one involved making the system provide real-time data (updates every 30 secs at most).

-The third one involved using a Bluetooth terminal to design and build a user-friendly digital interface that visualizes data for non-technical users.

-The fourth one involved the storage of the data of the system for at least one year of continuous operation.

-The fifth one involved using an alert to notify when reaching the threshold.
-The sixth involved running the sensors on a battery which must be able to operate continuously for at least 6 months without replacement of the battery.
-The seventh involved providing the system with light and its demand for electricity from renewable sources.
-The last one involved making a technical report explaining sensor integration, signal interpretation techniques, and the performance of the system in a test environment.

➢ Selection of Solution

The solution involves utilizing a multi-sensor system integrated into a greenhouse, focusing on four sensors. The first sensor is a soil moisture sensor, which manages soil humidity by controlling a water pump; when humidity increases, it activates the pump to irrigate the soil. The second is a light intensity sensor that adjusts the brightness of a light bulb to meet the specific light and heat requirements of each plant. The third sensor monitors air quality, specifically detecting harmful gas concentrations, such as carbon dioxide, within the greenhouse, using solar panels to support the system with renewable sources of energy. The fourth and last one is the temperature sensor, which will deal with temperature and humidity.

Key design requirements for this project include the use of an alternative energy source to extend battery life for at least six months of continuous operation. Additionally, a Bluetooth module will be implemented to transmit data to a mobile application, with data storage lasting up to a year. We also plan to incorporate alerts for two of the sensors to notify users when thresholds are exceeded. Finally, we will generate a report to present the data in an easily understandable format for all users, not just those with technical expertise.

The solution will be located in Al Minya, Upper Egypt, leveraging the region's fertile soil and favorable weather conditions. The soil of Upper Egypt provides ideal conditions for cultivation, while the warm climate with ample sunlight accelerates growth and enhances crop yields. This strategic location maximizes the solution's efficiency and potential impact on agricultural productivity.

➢ Selection Prototype

The prototype design for our greenhouse has been carefully selected to optimize plant growth and environmental control. The structure will be a cuboid container topped with a dome, constructed from glass for the walls and plastic for the dome. This design maximizes sunlight exposure while providing a controlled environment for the plants.

To power the greenhouse, we have integrated a solar panel system. This solar panel, shaped to fit the dome, converts solar energy into electricity, ensuring a sustainable power source that can extend battery life for at least six months. The strategic placement of the solar panel above the greenhouse facilitates even temperature distribution throughout the structure.

Our feedback control system incorporates four key sensors, all positioned inside the greenhouse. The first is a soil moisture sensor, which monitors soil humidity and transmits data to a mobile application. Based on these readings, an Arduino microcontroller activates a water pump to irrigate the soil when moisture levels drop.

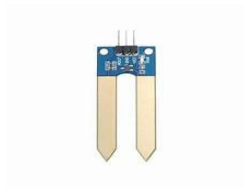
Additionally, an air quality sensor (MQ_135 sensor) monitors carbon dioxide levels within the greenhouse, ensuring a healthy environment for plant growth. The third sensor measures light intensity, triggering a buzzer to alert users when adjustments to the internal lighting are necessary. The last sensor is the temperature sensor (DHT-22) to deals with changes in temperature and humidity.

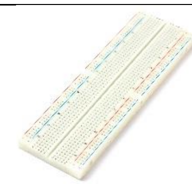
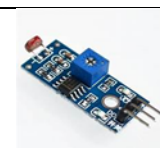
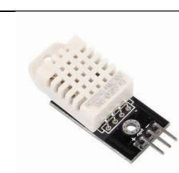
All components are connected via a breadboard, with data transmission facilitated by a Bluetooth module to the mobile application. This system not only allows real-time monitoring but also enables data storage for up to one year, providing valuable insights into the greenhouse's performance and conditions. This comprehensive approach combines technology and sustainability, enhancing the efficiency of greenhouse management.

Constructing and Testing a Prototype

Materials

Table (1): Materials

Name	Description	Quantity	Cost	Picture
Palm Frond	The ceiling of the greenhouse is due to its properties.	3 Stalks	50 L.E	
Plastic Sheets	Cover the whole greenhouse to isolate it from the air condition around it.	2	50 L.E	
Soil Moisture Sensor	It estimates volumetric water content.	1	75 L.E	
H-bridge	Is the simple circuit that lets us control the DC motor to go backward and forward.	1	100 L.E	

Solar Panels	It helps convert solar energy into electrical energy.	1	200 L.E	
Solar charger	A device used to charge a battery by regulating and monitoring the flow of electricity from solar panels to the battery.	1	90 L.E	
Convertor	Connected to the solar panel to boost the voltage from 5 to 12 (which is the voltage of the rechargeable batteries).	1	70 L.E	
Arduino UNO	An electronic board consisting of an electronic circuit containing a microcontroller.	1	450 L.E	
Bread Board	A board is used as a base for connecting electronic components to build electronic circuits with the possibility of changing the design.	1	30 L.E	
Water Pump	It transports water from one location to another	1	75 L.E	
Light Intensity Sensor	It detects the intensity of the light in the bulb	1	40 L.E	
DHT-22	It measures temperature and humidity.	1	150 L.E	
Light bulb	It is used to light a dark space	1	50 L.E	

Batteries	Rechargeable battery	3	100 L.E	
MQ-135	It senses the gases, especially CO2.	1	70 L.E	
Buzzer	The alert in the system.	1	30 L.E	
HC-05-Bluetooth module	It is used to facilitate sending and receiving data wirelessly with any microcontroller.	1	200 L.E	
Jumpers and USB cable	It acts by connecting two points or terminals using a jumper cable and data transformation is supported by USB plug-and-play.	1 USB 60 jumpers	70 L.E	

Total Cost = 1900 L.E

➢ Methods

The project methodology consisted of several steps, including the construction of the greenhouse, the installation of sensors, and the implementation of a feedback control system.

- As shown in **Fig (1)**, the base consists of a plastic box used to hold the soil and basil.

- The design of the dome was selected to optimize the distribution of heat within the greenhouse

Fig (1): shape of greenhouse

- Palm fronds were selected as the base of the dome due to their flexibility and strength, after which the dome was covered with plastic sheets.

These material selections were made based on scientific considerations of their specific advantages and properties. Overall, the methodology aimed to create optimal conditions for any plants within the greenhouse, in order to achieve the design requirements successfully.

Feedback control system:

First, the solar panel was connected to its charger then connected to the battery and the converter to elevate the output voltages of the solar panels to 12 volts which will feed the system.

In the feedback control system, multiple sensors were utilized as shown in **Fig (2)**, including a temperature sensor (DHT22), light intensity sensor (photoresistor sensor), soil moisture, and air quality sensor (MQ-135), connected to specific pins on the Arduino UNO and breadboard. When the measured intensity reached the specified threshold, the buzzer activated to provide an alert. An H-bridge was utilized to interface with the water pump, which controls the irrigation of the soil when the moisture increases. The whole system was linked to the smartphone through a serial Bluetooth terminal mobile application for the continuous monitoring of the recordings. To save these historical data there was a connection between the system and Tera-Term application to represent these data in simple form via Excel Sheet.

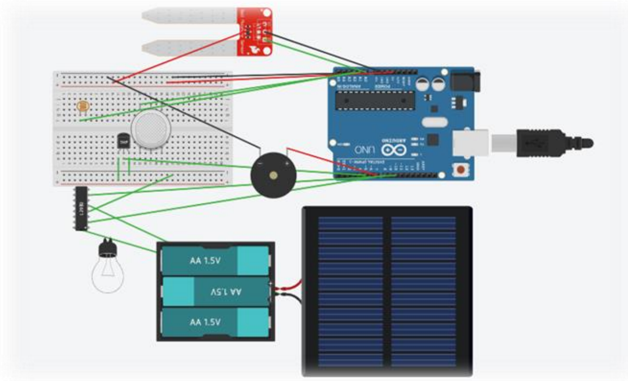


Fig (2): sensors connections

➢ Test Plan

The performance and effectiveness of the prototype, that's includes the Soil Moisture sensor with water pump action, MQ-135 gas sensor, light intensity sensor and its action buzzer, and DHT 22, are all tested under conditions and are clearly displayed in **Table (2)**.

Table (2): Testing the prototype

Type of sensor	Way of testing
MQ-135	▪ To assess the sensor by concentrating on the variations in the CO_2 concentration readings between day and night.
Light intensity	▪ Must link the light intensity sensor to a buzzer and switch it on or off according to the threshold to evaluate its functionality.
Soil moisture	▪ By placing the soil moisture sensor in the soil, to verify its performance. The water pump will then operate automatically based on the threshold.
DHT22	▪ To test DHT 22's accuracy, turn on and off the lightbulb that controls the greenhouse's temperature

➢ Data Collection

The measurements and the tools which used:

-Soldering iron (from Fabrication lab)
-Screwdriver (from Fabrication lab)
-Voltammeter (from Physics Lab)
-Jumper wires (from Electronics Lab)

By finishing the construction of the greenhouse, and testing the connections of the sensors and the overall software, and hardware circuits through a series of organized steps; successful results were obtained as shown in **Table (3)**.

Table (3): **Actions due to conditions**

The condition	Action
Soil moisture value > 200	▪ The water pump will be turned on.
Soil moisture value < 200	▪ The water pump will be turned off **(No action will be taken)**.
light intensity value > 250	▪ Buzzer will be turned on as an alert (which is considered one of the design requirements).
light intensity < 250	▪ Buzzer will be turned off **(No action will be taken)**.

As shown in **Fig (3)** these are several readings of the light intensity and temperature sensors after and before turning on the bulb (the x-axis represents a definite number of readings and the y-axis represents the light intensity and the temperature).

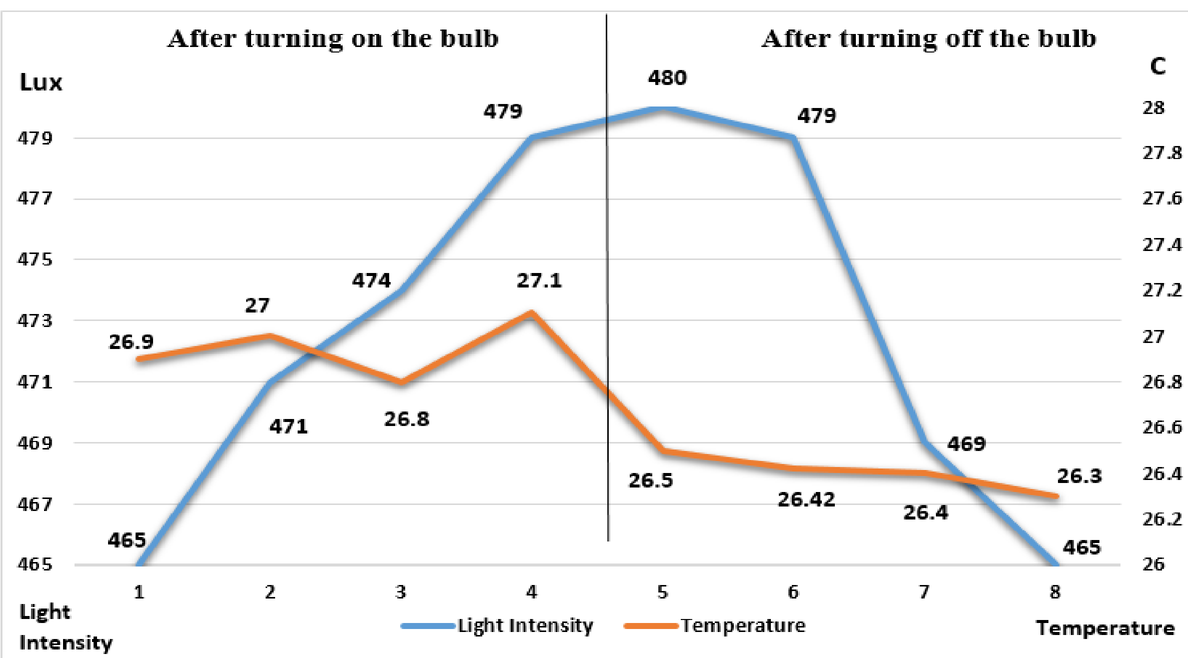


Fig (3): readings of temperature and light sensors before and after turning on the bulb

For easy, simple access and monitoring of the greenhouse and the soil, the system was connected to a smartphone mobile application which is: **Serial Bluetooth Terminal** using Bluetooth module for continuous recordings of the sensors' readings and observations during each test as shown in **Fig (4)**.

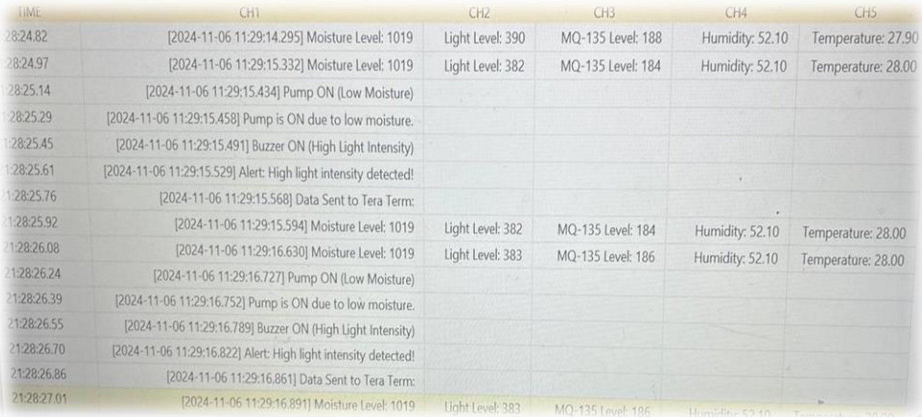


Fig (5): saved data and readings

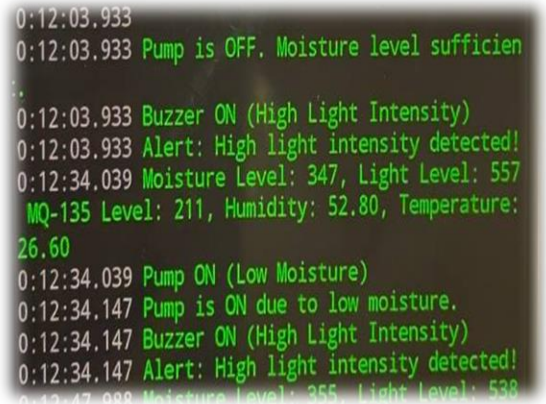


Fig (4): data in serial Bluetooth terminal

The data is supposed to be shown continuously every 30 seconds and is saved automatically in the **Tera-Term application**, which achieved one of the desired design requirements which is the storage of the data of the system for at least one year of continuous operation. The data was presented in an Excel sheet as shown in **Fig (5)** to facilitate the readings for non-technical users.

Evaluation, Reflection, Recommendations

➢ Analysis and Discussion

Egypt is currently facing an extremely difficult mission, figuring out how to use new technology and modern development methods that can both help in our daily lives, this semester's main concerns are reducing pollution, combating climate change, strengthening Egypt's economic and agricultural bases, and enhancing the environment for everyone who uses science and technology. To deal with these major issues, an autonomously intelligent building should be constructed.

The solution involves a greenhouse, which is divided into two main components: the feedback system and the building construction method. Extensive research has been conducted to create a greenhouse that supports the cultivation of various annual crops requiring specific growth climates. The prototype features a base made from a plastic box connected to a plastic sheet with a palm leaves dome, chosen to maintain internal temperatures unaffected by external weather conditions, the feedback system utilizes multiple sensors to meet the initial design requirements. The first sensor, a soil moisture sensor to regulate moisture and dryness of soil with a connected water pump, helping to reduce water consumption.

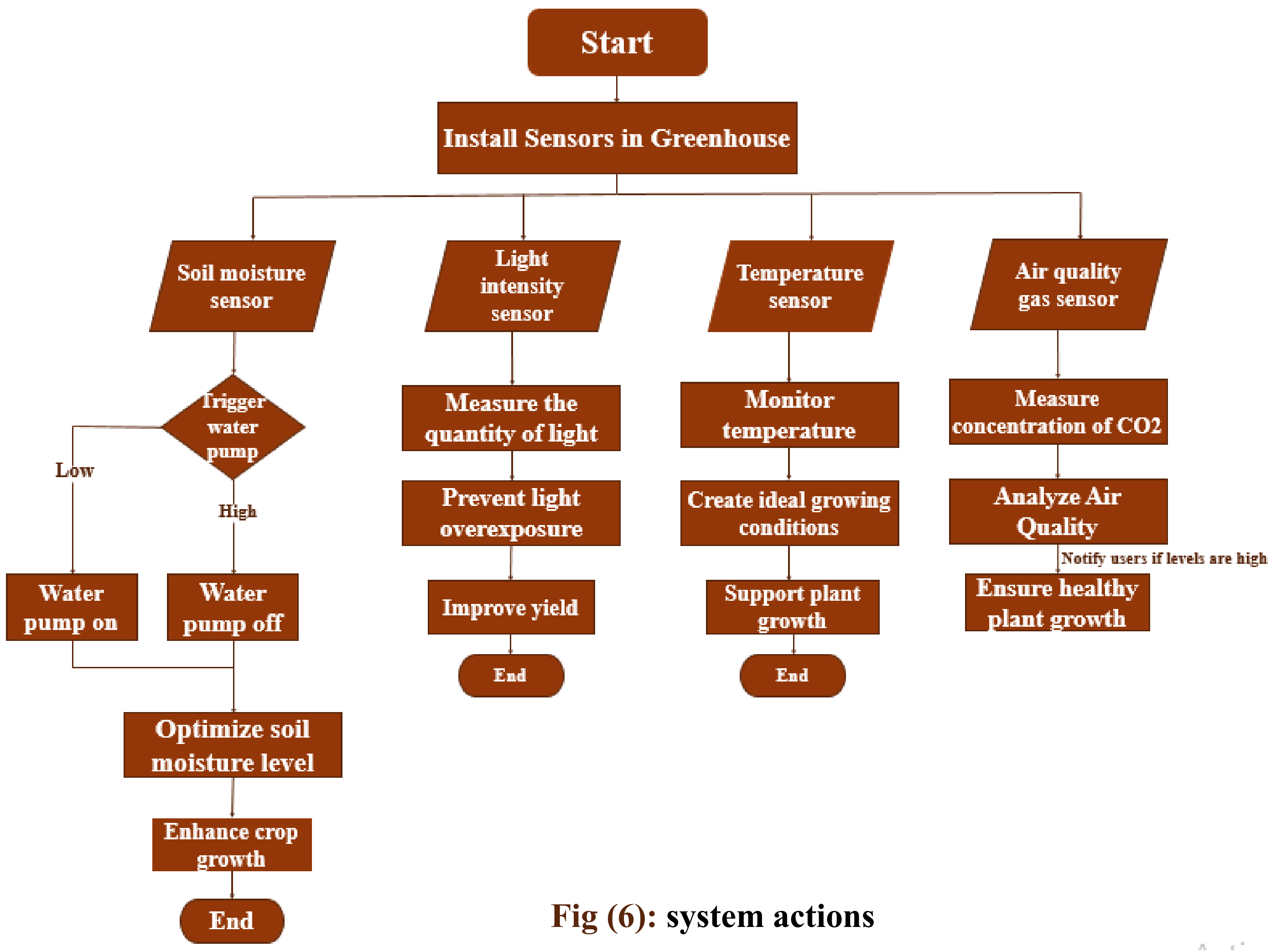


Fig (6): system actions

The second sensor, a light intensity sensor regulates the level of light that plants need with the alert buzzer if the intensity is higher than the threshold. The third sensor, a temperature sensor, measures the internal temperature generated by the light bulb, while the fourth, an air quality gas sensor, monitors carbon dioxide emissions from plants day and night, tracking concentration changes as shown in **Fig (6)**.

To satisfy the second design requirement, the system's batteries must last at least six months without replacement. This project is powered by renewable energy to extend battery life through silicon solar panels, which absorb sunlight and convert it to energy, in accordance with the law of conservation of energy **(CH.3.01)**: “Energy can neither be created nor destroyed but only converted from one form to another.”

The efficiency of solar panels varies throughout the day, being lower in the morning, peaking at midday, and decreasing in the afternoon due to factors like the sun's angle and position. These variations must be considered in the design of solar energy systems for optimal performance.

Lithium-ion batteries typically offer around 6000 cycles, meaning they can be discharged and recharged 6000 times before experiencing significant degradation. A "cycle" refers to discharging the battery and recharging it. The remaining capacity of a battery, often referred to as the "aging index," indicates how much usable power is left. For calculating the life of the battery for this system the battery will have 2 cycles per day so dividing the whole cycles over the cycle per day $\frac{\mathbf{6000}\ \boldsymbol{cycles\ for\ battery}}{\mathbf{2}\ \boldsymbol{cycles\ per\ day}} = \mathbf{3000}$ **cycles (means 3000 days)**, then to know the time it will stay before damaging or replacing $\frac{\mathbf{3000}}{\mathbf{365}\ \boldsymbol{days/year}} = \mathbf{8.21}$ **years**, so achieving the design requirement of using the same battery for at least 6 months due to the cycles consumed on the 6 months which is calculated using this rule: $\mathbf{2}\ (\boldsymbol{cycles\ per\ day}) \times (\mathbf{6}\ \boldsymbol{months}\ \times \mathbf{30}\ \boldsymbol{days\ in\ month}) = \mathbf{360}$ **cycles per 6 months**, which indicate that the lithium-ion battery was the better type for this project. Battery efficiency is a crucial factor in supplying power to the system. Most lithium-ion batteries have an efficiency rate of 95% or higher.

Once the prototype is completed, data will be collected continuously for at least a year, with updates every 30 seconds to meet additional design requirements. This data will be transmitted via the Tera-Term application, which automatically saves it in an Excel sheet and generates graphs to create a user-friendly digital interface for non-technical users.

After implementing the feedback system, the following results were observed:

Positive Results:

- Both the hardware and software of the greenhouse project were tested and successfully met design requirements, with all components, including sensors and actions, functioning as expected.
- The water pump activates to reduce soil moisture when necessary.
- The light bulb provides heat and light to support greenhouse conditions.
- Heat is efficiently preserved inside the building by plastic sheets.
- Data is organized in an Excel sheet with graphs, creating an accessible digital interface.

Negative Results:

- The efficiency of solar PV decreases with temperature increases, dropping by 0.4% to 0.5% for each degree Celsius above 25 °C.
- The Bluetooth module has limited range, only transmitting notifications within the building and not suitable for sensor readings over distances of 10 meters.
- To overcome the difficulty of solar panels which operate on 5 volts, that are able to recharge only one 4-volt lithium-ion battery at a time, a converter was connected to the solar panel in order to increase the voltages that the panel emits to the batteries.

While working on the system and testing it, the precision **(Zumdahl, S. S., & Zumdahl, S. A., 2014, p. 12-13)** and the rate of change were put into consideration to achieve and reach an efficient result. Accordingly, three trials were conducted to compare the readings of the temperature sensor and the light intensity sensor and calculate the difference between their readings.

Using **(MA.2.07),** the average rate of change was calculated using this formula: $y4 - y1 / x4 - x1$ = 479-465 / 27.1-26.9 = 70, as $y4$ and $y1$ represent the final and initial value of light intensity respectively and $x4$ and $x1$ represent the final and initial value of temperature respectively (these values are taken after turning on the bulb). The value of the rate of change obtained was 70, meaning that as the light intensity changes by 70 lux, the temperature changes by 1 degree Celsius, as shown in **Fig (7)**.

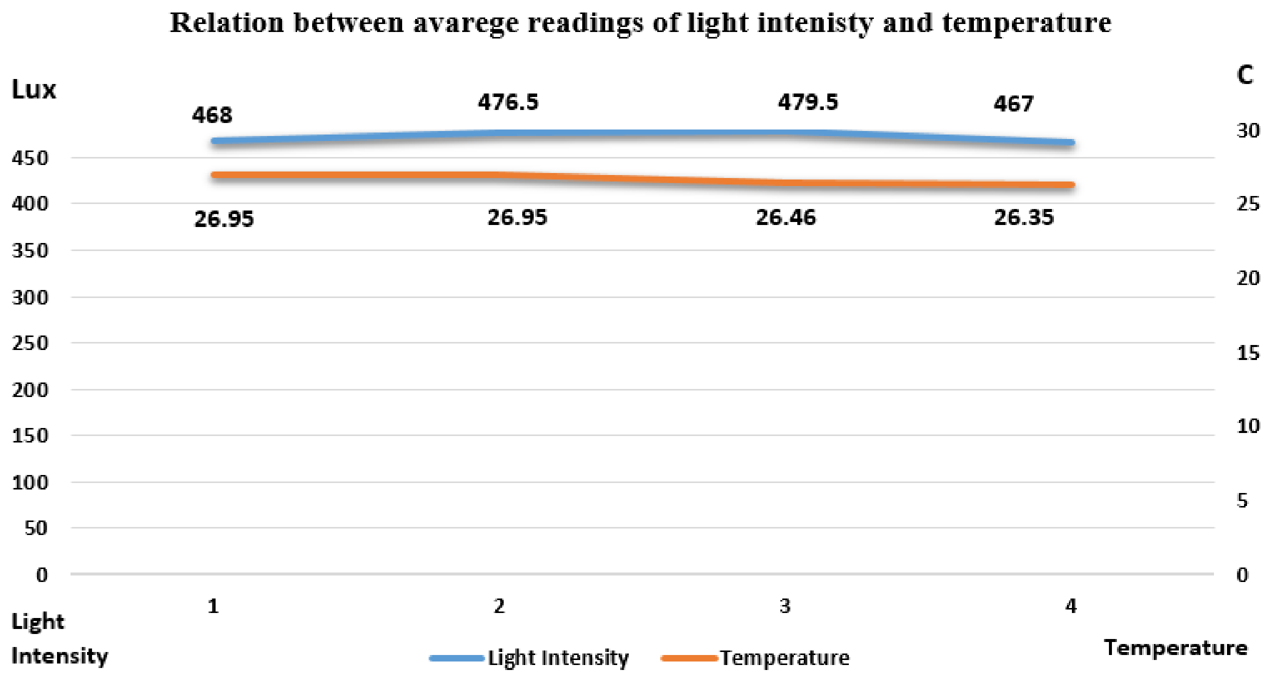


Fig (7): relation between average readings of light and temperature sensors

Applying **(CH.3.01),** the several readings of the sensors show that the precision value between 472 and 473, is calculated by using this formula: (the total of the measured values / the number of these values). It indicates that the reading values are close to each other.

(MA.1.02) was used in calculating the average "mean" of a group of values using this formula: $\boldsymbol{sum\ of\ values\ / their\ number}$ = 479+474+471+465 / 4 = 472.25, it used also while calculating the precision.

➢ Recommendations

1. Use electric conductivity sensors to accurately measure soil nutrient levels, enhancing understanding of nutrient availability for optimal plant growth.

2. Incorporate pesticide sensors to determine the suitable soil concentration for effective pest control while minimizing environmental impact.

3. Integrate movable solar panels to maximize sunlight collection, improving energy efficiency and output in solar systems.

4. Adopt Bi-Directional Logic Converters for large-scale applications to facilitate communication between different logic levels in complex systems.

5. Utilize pH meters to assess soil acidity, aiding in the selection of appropriate plants for better growth and yield.

Learning Outcomes

Biology

(BI.3.02) we studied how information processing, sensory neurons transmit information from sensors then neurons in the brain or ganglia integrate the sensory input. Then leading to a motor response. Similar to our project, the sensors detect the specific stimuli then integrate them, and finally give a reaction as a buzzer.

(BI.3.02) we investigated the functioning of the nervous system, particularly how information such as names, phone numbers, and factual data are stored in long-term memory and can be retrieved. In our project, an Excel sheet serves a similar purpose, acting as a long-term memory system where data can be saved and recalled when needed.

(BI.3.03), Thermoreceptors are specialized sensory receptors that detect variations in temperature, both heat and cold. Similarly, in our project, a temperature sensor functions analogously to a thermoreceptor, effectively detecting and measuring heat.

Physics

(PH.3.02) there are various types of waves, including light, which is classified as a transverse wave. This type of wave does not require a medium for propagation, allowing it to travel through the vacuum of space at high velocities. The light emitted from a bulb serves as an example of such a wave.

(PH.3.05), we focused on communication processes involving the broadcasting, transmission, storage, and display of data using electronic devices and circuits. Our project mirrors this concept by effectively transmitting and storing data, presenting it in a user-friendly format for non-technical users.

Geology

(ES.3.02) The Global Positioning System (GPS) is a satellite-based system for the accurate location of points on Earth by using three satellites at least and then detecting the intersection points to locate the project.

Chemistry

(CH.3.01): "Energy can neither be created nor destroyed but only converted from one form to another."

(CH.3.01): Knowing the precision values.

Math

(MA.2.07), calculating the average rate of change.

(MA.1.02) was used in calculating the average "mean" of a group of values using this formula: $\boldsymbol{sum\ of\ values\ /their\ number}$.

➢ List of Sources in APA Format

- Sinfield, J. V., Sheth, A., & Kotian, R. R. (2020). Framing the intractable: Comprehensive success factor Analysis for grand challenges. Sustainable Futures, 2, 100037. https://doi.org/10.1016/j.sftr.2020.100037
- Lindwall, C. (2022, October 24). What are the effects of climate change? Effects of Climate Change – Impacts and Examples. Retrieved April 4, 2023, from https://www.nrdc.org/stories/what-are-effects-climate-change.
- Tan, P., Gebremariam, E. T., Rahman, M. S., Salman, H., & Xu, H. (2022). Design and Implementation of Soil Moisture Monitoring and Irrigation System based on ARM and IoT. Procedia Computer Science, 208, 486–493. https://doi.org/10.1016/j.procs.2022.10.067
- Madzhi, N. K., & Izulman, I. B. (2020). Light intensity and human-machine interface environmental control of a greenhouse system. AIP Conference Proceedings. https://doi.org/10.1063/5.0035305
- Li, H., Guo, Y., Zhao, H., Wang, Y., & Chow, D. (2021). Towards automated greenhouse: A state of the art review on greenhouse monitoring methods and technologies based on internet of things. Computers and Electronics in Agriculture, 191, 106558. https://doi.org/10.1016/j.compag.2021.106558
- Liu, B., Li, K., Niu, D., Jin, Y., & Liu, Y. (2017). The characteristic analysis of the solar energy photovoltaic power generation system. IOP Conference Series. Materials Science and Engineering, 164, 012018. https://doi.org/10.1088/1757-899x/164/1/012018
- Svarc, J. (2024, April 16). Most efficient solar panels 2024 — Clean Energy Reviews. Clean Energy Reviews. https://www.cleanenergyreviews.info/blog/most-efficient-solar-panels
- Halliday, D., Resnick, R., & Walker, J. (2013). Fundamentals of physics. John Wiley & Sons.
- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry. Cengage Learning.
- Congxinhe. (2024, June 25). How temperature impacts solar cell efficiency. Solar N Plus. https://www.solarnplus.com/how-temperature-impacts-solar-cell-efficiency/
- Tyrrell, R. (2024, August 7). 4 reasons why Lithium batteries win over Lead Acid for energy storage. Power Saving Solutions. https://powersavingsolutions.co.uk/4-reasons-why-lithium-batteries-win-over-lead-acid-for-energy-storage/#:~:text=Discharging%20a%20battery%20of%20power,battery%20generally%20has%202000%20cycles.