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DEUTSCHE ZUSAMMENARBEIT

nexus



# Agriculture through the Integration of Water, Energy, and Food Sectors

GEBAL Egypt  
March 2023

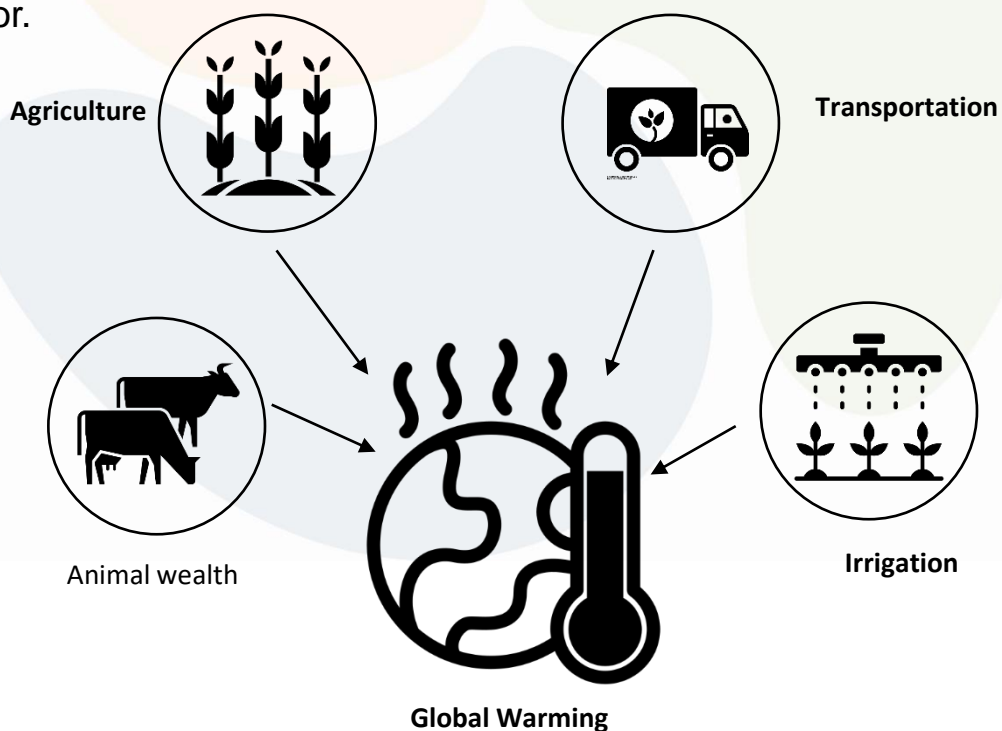


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# Many of us have heard or read about climate change. So, what is climate change, and what are some of its causes?

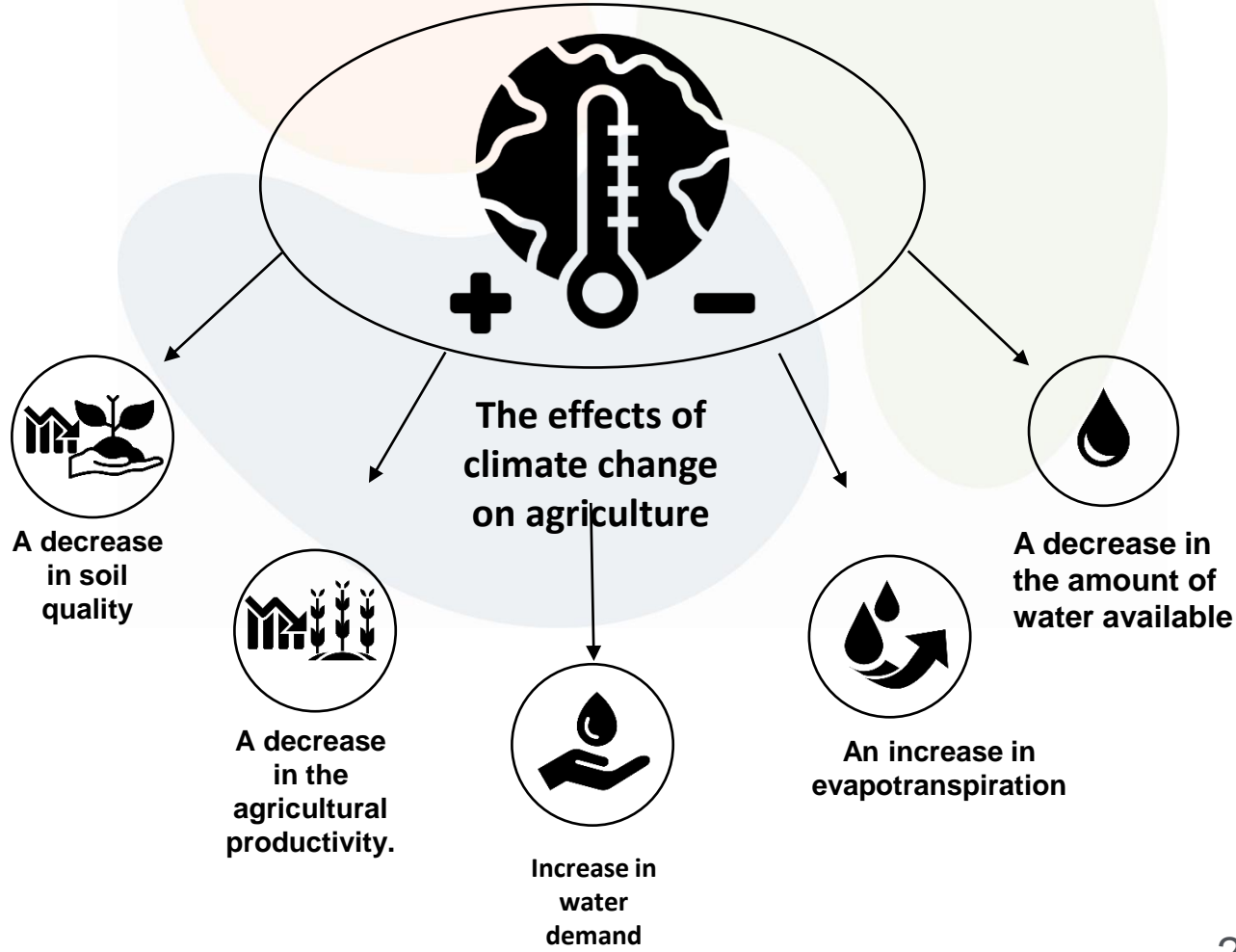
Climate change is the long-term change in the Earth's surface temperature that leads to long-term shifts in weather patterns. Climate change is already happening; it is not just a theoretical concept in books and lectures or the pessimistic predictions of some scientists. This could be the last chance to save planet Earth, the only planet where human life is possible. The agricultural sector, which includes crop production, irrigation, transportation, livestock and animal husbandry, is one of the sectors that contribute most to the phenomenon of global warming, which is one of the main causes of climate change. Global warming is the increase in temperatures on Earth (both land and water) due to the increase of greenhouse gases in the atmosphere, caused primarily by human activities, with the burning of fossil fuels being a major factor.



# Many of us have heard or read about climate change. So, what is climate change, and what are some of its causes?

Climate change and rising temperatures will directly affect the lives of people in general, and farmers in particular. Rising temperatures will lead to a decrease in water available for crops, increased evapotranspiration, a rise in water demand, a potential decrease in agricultural productivity, a decrease in soil quality and organic matter, and expected changes in crop yields.

Rising temperatures also mean that temperatures will make farming in some growing environments in Egypt very difficult, particularly during the hot summer months. Models show a decrease in agricultural productivity due to climate change. Thus, farmers in Egypt will have to adjust their agricultural processes in preparation for climate change impacts.



# The integrated agriculture project combining the sectors of water, energy, and food

Is it conceivable that Egypt, blessed with the Nile, should be considered water-scarce? The Nile is the main source of renewable water (97%) in Egypt, and Egypt's annual share of Nile water remains constant at 55.5 billion cubic meters. Therefore, the per capita share of renewable water is less than 600 cubic meters annually, which is below the water poverty line estimated at 1,000 cubic meters per person per year. Given the threats posed by climate change and its impact on rainfall patterns, timing, and amounts, food security is becoming one of the most important issues that should concern all those interested in Egypt's public affairs. This is because food security is not only about the availability of food at certain times or seasons, but also includes the following elements: availability of food, facilitation of access to food, improvement of nutrient utilization by the body (food quality and diversity), and stability, which refers to the presence of food security and the possibility of having access to a diverse and nutritious diet for all people at all times.

Therefore, GEBAL, in partnership with the German International Cooperation Agency (GIZ), Dandara Development Center, and El Heiz Water Education Center, and with funding from the European Union and the German Government (BMZ), launched a project titled "Integrated Agriculture: Water, Energy, and Food Nexus" in the summer of 2022.



Integrated agriculture, which combines water, energy, and food, provides a future-oriented solution to many of the agricultural challenges facing our world. Integrated agriculture makes the most of all resources used in the agricultural process. Using resources and waste products in a circular way creates co-benefits between them, leads to savings in fertilizer and pesticide use, a reduction in energy use and CO2 emissions, a protection of biodiversity, and the long-term enhancement of soils and ecosystems. This type of agriculture also focuses on water conservation by making the most efficient use of every drop of water used in agriculture. This starts with modern irrigation techniques and extends to water recycling to minimize water loss. Water scarcity is one of the biggest challenges for the future, especially in Egypt, and requires the introduction of innovative solutions to conserve and maximize water use.



# Integration of water, energy, and food

In addition, the integration of water, energy, and food in agriculture provides an ideal solution to address the phenomenon of climate change. This system utilizes fish outputs from the fishpond integrated with the greenhouse during the irrigation process, serving as organic fertilizer that helps the soil obtain natural nutrition. It also maintains the carbon cycle in the soil, which can be disrupted by the use of synthetic fertilizers and pesticides, both of which are rarely used in greenhouse agriculture. Moreover, utilizing solar energy as a renewable energy source for managing and operating these greenhouses offers a practical and sustainable solution to the challenges of climate change, while also providing long-term economic benefits.

Farming inside protected greenhouses improves economic sustainability for farmers. They can utilize a smaller land area to cultivate a larger quantity of crops by practicing protected agriculture. Additionally, fish and crop production integrated within one greenhouse can be economically beneficial through the sale of more than one crop. Moreover, specifically climate-controlled greenhouses offer opportunities to sell at higher price outside the common agricultural seasons.



# Models of agriculture through the integration of water, energy, and food

There are two types of agricultural greenhouses implemented by GEBAL with the aim of enhancing the link between water, energy, and food to achieve integration of these important sectors.

These two types are:



A model of the cooled agricultural greenhouses.

## Climate-controlled greenhouse model

Covering an area of 640 square meters, the climate in the cooled agricultural greenhouses is controlled to achieve an optimal climate for the plants to maximize productivity. Temperature control is possible by raising the temperature above the preset limit through control panels, activating air extraction units to remove hot air from inside the greenhouse and replace it with cooler air from outside the greenhouse, which is passed through cooling cells to lower the temperature. After a few minutes, all the hot air is replaced by cool air inside the greenhouse. When the temperature reaches the optimum value preset in the control panel, all exhaust systems and the cooling pumps stop operating.

The total power required to operate the cooling fans and cooling pump is 7 kilowatts, and all the power is supplied by solar panels. The solar panels generate the electricity needed for the energy needs of the greenhouse.

The cooled greenhouse model includes a water tank with a capacity of 36 cubic meters to store water for irrigation purposes. This water is also used for raising tilapia fish or catfish in the greenhouse. The water capacity is sufficient for about 3,000 fish, and during the farming season, the fish waste is used as a source of nutrients for the plants in the greenhouse. The fishpond can produce up to 750 kilograms of fish.

# Models of agriculture through the integration of water, energy, and food

In addition, this greenhouse is irrigated by a drip irrigation system to preserve every drop of water supplied to the plants, and the irrigation water is pumped by a submersible pump with a power of only 0.25 kilowatts. This is enough to irrigate the 640 square meter greenhouse and this pump, like all systems of this model, is powered by solar energy.

This greenhouse can produce more than 40 kilograms of vegetables per square meter of area in the greenhouse. In addition, the greenhouse has an underground agricultural drainage network that drains excess water and returns it to the water reservoir used for plant irrigation. This creates a closed water cycle, and every drop of water is used optimally.

## The tunnel greenhouse model



The tunnel greenhouse model.

The tunnel greenhouse is equipped with a 63% shading net and an additional secondary plastic covering layer. In this type of greenhouse, the climate is manually controlled by using the black net to reduce the temperature in summer and the plastic cover for internal heating in winter. In addition, this greenhouse has a polyethylene water tank with a capacity of 12 cubic meters. Irrigation is done by drip irrigation from the water source in the water tank of the greenhouse with the help of a submersible pump with a capacity of 0.25 kilowatts, which is powered by solar energy to irrigate the entire 320 square meter greenhouse. The water tank for irrigation is also used for fish farming, with a capacity of up to 1,000 fish that can produce 200 kilograms of fish annually.



# Models of agriculture through the integration of water, energy, and food.



The tunnel greenhouse model.

The tank is aerated with a solar-powered aeration pump. An agricultural drainage system is also installed in the greenhouse to return excess water from irrigation to the water tank for reuse. This greenhouse can produce about 20 kilograms per square meter of greenhouse area annually.

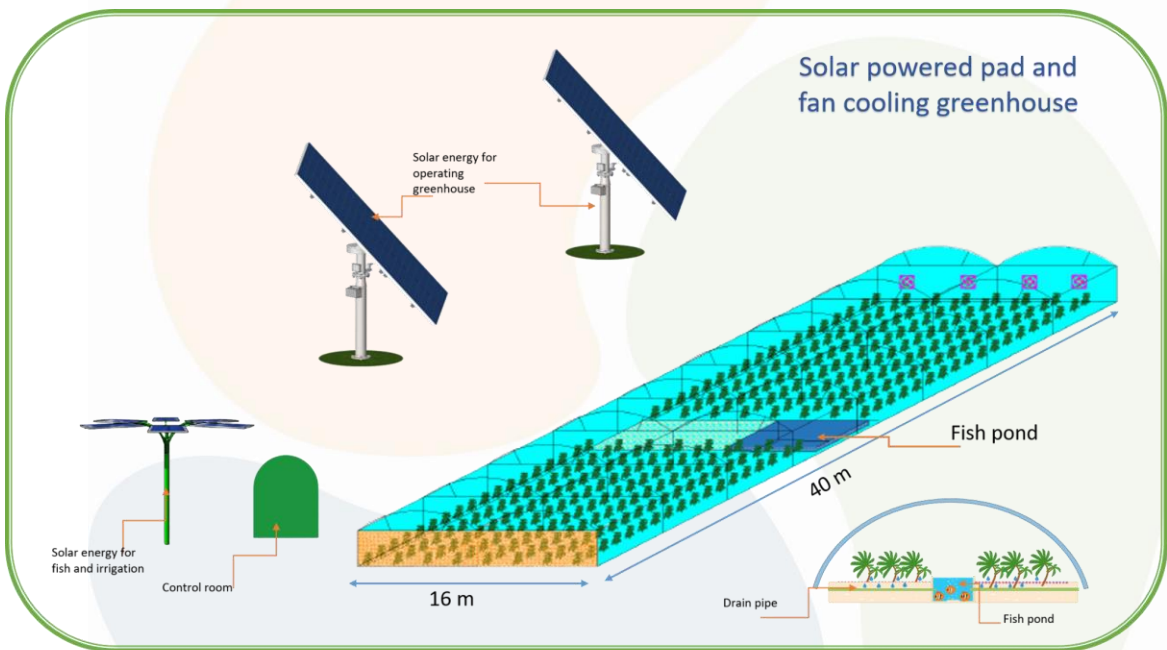
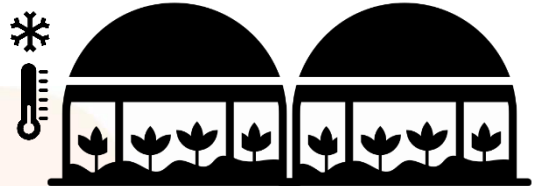
Both models will be explained in greater technical detail in the following section.

It should be mentioned that greenhouses are not the only nexus farming solutions, but that GEBAL has tested the performance of these nexus farming greenhouses in Egypt. For more information about other types of nexus farming, for example on an open field, please contact GEBAL. We are happy to but you in touch with the relevant experts and partners.

# Protected agriculture in water-energy-food nexus greenhouses

The two types of agricultural greenhouses used by GEBAL to improve the connection of water, energy and food resources are based on specific designs to make this connection effective and ensure its realization.

.The first model is the cooled greenhouse:

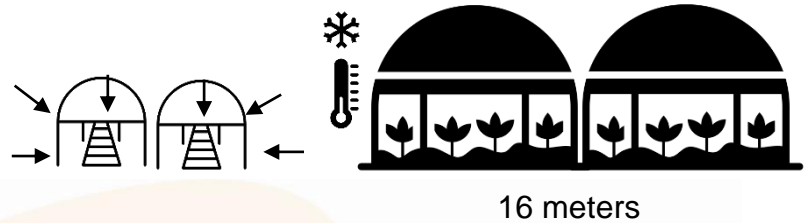


# Protected agriculture in water-energy-food nexus greenhouses

**Greenhouse dimensions:** 16 meters width and 40 meters length, totaling an area of 640 square meters.

**The components:**

**Technical specifications:**



**The metal structure:**

**Dimensions:** Length 40 meters, width 16 meters, 2 gables with a width of 8 meters, side height 2.70 meters, maximum height 4.55 meters.

**Arches:** There are 17 arches made of 1.5-inch galvanized pipes, internally and externally hot-dipped, with a thickness of 2mm.

The distance between repeated arches is 2.50 meters, and the distance between the first and second arch, the last arch, and the second-to-last arch is 2 meters.

The tie rods consist of 8 galvanized pipes, 3/4 inch in diameter, with a thickness of 2 mm.

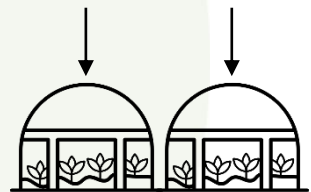
The reinforcement includes 8 diagonal supports, 12 longitudinal supports, and 6 X-shaped supports, all made of galvanized pipes, 3/4 inch in diameter.

Each arch has a plant hanger made of galvanized pipes, 3/4 inch in diameter, except for the first and last arches, which have plant hangers made of galvanized pipes, 1.5 inches in diameter.

The connections are made without welding or screws using a galvanized telescopic coupling system.

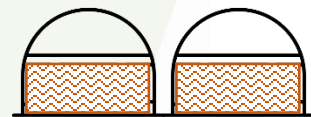
# Protected agriculture in water-energy-food nexus greenhouses.

- The stakes are made of 1.5-inch and 2-inch galvanized pipes with a length of 60 cm, similar to the diameter of the arches.
- The wires: Eighteen galvanized wires with a diameter of 2mm and 14 are stretched on the roof of the greenhouse.
- Ventilation: The sides are manually opened completely with a height of 1.5 meters, and the openings are covered with white insect netting (anti-virus).
- Doors: There are two rooms, each with a double door. The inner door is sliding and opens on both sides with a width of 2 meters, while the outer door is hinged and opens with a width of 1 meter. They are installed in the middle of the sides of the greenhouse, in front of the central aisle or as per the instructions.



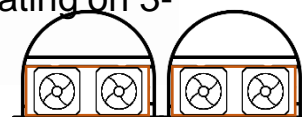
## 1. The cover

1. Polyethylene treated with a thickness of 200 microns.



## 2. Cooling

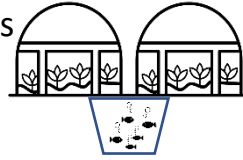
1. Four large fans, with a capacity of approximately 42,000 m<sup>3</sup>/hour, powered by a 1.5 horsepower motor, operating on 3-phase current.



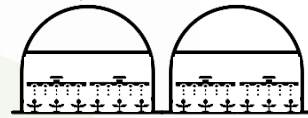
2. 32 square meters of cooling cells, with a thickness of 10 CM.
3. 16 meters of galvanized steel basins with top and bottom electrostatically coated, and a ground wall is constructed to support the moisture basins of the cells.

# Protected agriculture in water-energy-food nexus greenhouses.

- 1 water tank with a capacity of 1 cubic meter and 1 submersible water pump with a capacity of 1.5 horsepower.
- 1 control and protection panel for the fans and pump that operates automatically based on a thermostat.
- **Fish tank:** It is a cement tank built with bricks, with a depth of 1.5 meters, length of 6 meters, and width of 4 meters, which is equivalent to 36 cubic meters of water.



**1. Fish:** All available fish can be used for aquaculture in this tank, from Nile tilapia to shrimp.



**2. Irrigation:** It is a drip irrigation system consisting of self-pointed hoses that discharge 4 liters per hour, with a spacing of 0.3 meters between the emitters. The greenhouse has 20 hoses, equivalent to 2700 emitters. A submersible pump is installed in the fish tank to irrigate the greenhouse. Additionally, another submersible pump is installed to circulate and aerate the water for the fish.

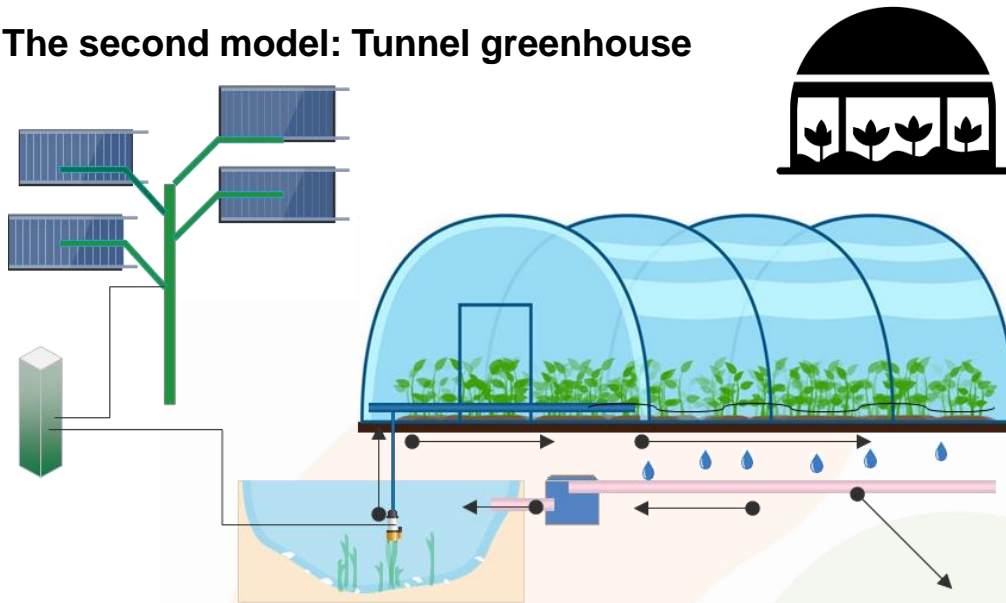


**1. Solar Power:** A 10-kilowatt solar power system is installed and connected to 2 inverters to convert the power from DC to AC at 380 volts. This system is responsible for powering 4 cooling fans, each with a capacity of 1.5 horsepower, as well as a 1.5-horsepower cooling pump. Two fans are connected to one converter, and another two fans and a cooling pump are connected to the second converter. Additionally, 2 kilowatt solar panels are installed specifically for the irrigation pump and the fish ventilation pump. These panels are connected to batteries for energy storage, allowing the system to operate 24 hours a day. The output current of this system is 220 volts.

**Plants:** This greenhouse can accommodate 3,000 plants for cultivation.

# Protected agriculture in water-energy-food nexus greenhouses

## The second model: Tunnel greenhouse



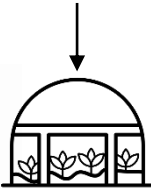
### 1. Metal Structure Specifications:

- Length: 40 meters, Width: 8 meters, Height: 3.15 meters.
- Number of arches: 17 arches, galvanized hot pipes with a diameter of 1.5 inches.
- The supports are installed using 3/4-inch galvanized hot pipes.
- The greenhouse is supported by 2 inclined supports and 4 longitudinal supports made of 3/4-inch galvanized hot pipes.
- Plant hangers are made of 3/4-inch galvanized hot pipes, except for the first and last ones which are made of 1.5-inch galvanized hot pipes.
- The connections are made without welding or screws using a galvanized tensioning system (telescopic system).
- Wedges: 1-inch hot galvanized pipes.



# Protected agriculture in water-energy-food nexus greenhouses

- The wires: There are 28 galvanized wires with a diameter of 2mm on the greenhouse.
- Plant wire: There are 12 galvanized wires with a diameter of 2mm installed above the plant hangers.
- Doors: 2 hinged doors in a 2-meter room for both sides, from the inside a sliding door opens in each room on two wings with a total width of 2 m.

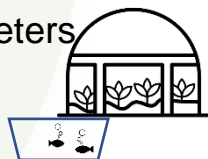


**The cover:** Polyethylene processed with a thickness of 200 microns, and a shading net cover of 73%.

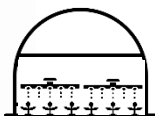


**Side ventilation:** Curtains on the sides open to a height of 1.25 meters, and the opening is covered with a virus-proof mesh.

**Fish Tank:** It is a polyethylene tank with a depth of 1.2 meters, a length of 3.5 meters, and a width of 3.5 meters, equivalent to 12 cubic meters of water.

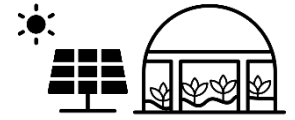


**Fish:** All available fish can be used for farming in this basin, from Nile tilapia to shrimp.



**Irrigation:** It is a drip irrigation system consisting of self-pointing hoses. Each point releases 4 liters per hour, with a spacing of 0.3 meters between the points. The greenhouse has 9 hoses, totaling 1100 points. A submersible pump is used, which is installed in the fish tank for irrigating the greenhouse. Additionally, another submersible pump is installed for water circulation to provide ventilation and oxygenation for the fish.

# Protected agriculture in water-energy-food nexus greenhouses.



## 1. Solar Power

A 1-kilowatt solar panel is installed specifically for powering the irrigation pump and the fish ventilation pump. These panels are connected to batteries for energy storage, allowing the system to operate continuously for 24 hours. The output current from this system is 220 volts.

**Plants:** It is possible to cultivate 900 plants in this greenhouse.

## Benefits of the Protected agriculture in water-energy-food nexus greenhouses

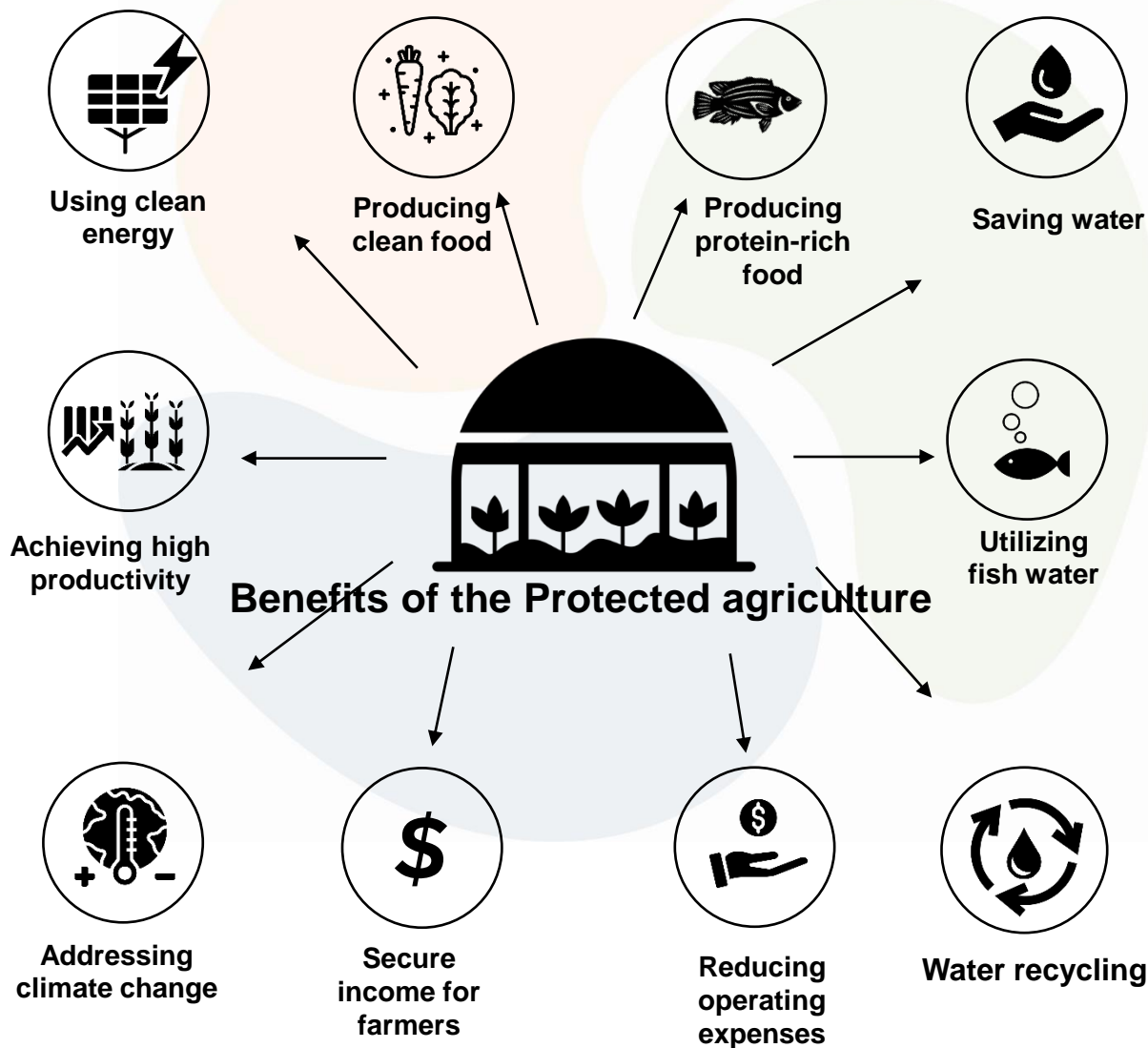
Water-energy-food nexus farming offers several benefits:

1. Conserving and preserving water through drip irrigation system.
2. Reusing water by recycling plant wastewater.
3. Maximizing water utilization by using it for fish before irrigation.
4. Producing clean food by utilizing nutrients from fish water.
5. Producing protein-rich food from fish, along with food from plants in the greenhouse.
6. Maximizing the utilization of cultivated space to achieve the highest productivity per square meter, reaching up to 40 kilograms annually in some cases.
7. Using clean energy to operate irrigation and crop production inside the greenhouse by harnessing solar energy.



# Benefits of the protected agriculture in water-energy-food nexus greenhouses

- 7. Reducing expenses by utilizing solar power instead of Diesel.
- 8. Addressing climate change by adapting the climate to produce the crops we need at the appropriate time.
- 9. Reducing carbon emissions by utilizing clean energy and maximizing the utilization of space and the maximum productivity of plants.
- 10. Ensuring a secure and fair income for farmers.



# How do you initiate your project to enhance the nexus of water, energy, and food while ensuring a profitable income for your farm?

1. Start by leaning more about the concept of integrated farming and how to apply it to your work.
2. Make a feasibility study for your project: What is the size of your land? What do you plan to grow? What type of integrated farming system do you want to implement? What are the costs involved? Create a business model and calculate the payback/return on investment time. Conduct a market analysis for your project. What is the most suitable technological solution for your land?
3. Create a design for your property (consult an engineer) - Survey the property and evaluate water and power sources (do you have a well? a canal? are you connected to the power grid?). Conduct soil and water tests. Decide on the best location for the agricultural greenhouse and placement of the solar panels (away from potential tree shading). Determine the best location for your fish tank. Where should the fish food come from (can it be produced locally)? Create a checklist for soil preparation.
4. Where will the funding come from? Create a financing plan and identify potential financing institutions. Are there loans/grants/investors/partners available? Study offers from different banks and financial institutions. Visit your local branch of the bank you deal with and inquire about options, or conduct research online, or refer to the available contact list below.

## How do you initiate your project to enhance the nexus of water, energy, and food while ensuring a profitable income for your farm?

5. Create a simple management plan for your land. Make a log to document the necessary data once the agricultural greenhouse is in operation. For example, record how much money you spent and on what, how much fertilizer and pesticide you used (if applicable), the cost of materials, labor, and fish food, the interest on bank loans, and how much was harvested. This way, at the end of the season, you can calculate whether you made a profit and determine the return on investment or the time to recoup the investment. One possibility is to create a spreadsheet to capture this information and make the appropriate calculations.

# Case study of water-energy-food nexus greenhouses

A large uncooled greenhouse model (or 4 small greenhouses) covering an area of 1440 square meters with a 12 cubic meter fish tank attached. The estimated price for this model in 2022 is 154,000 Egyptian pounds. Assuming that cucumbers are grown in the greenhouse, the annual yield is expected to be about 33 tons of cucumbers. It is important to distinguish between "on-site" sales and sales to high-end markets (such as supermarkets in major cities). When selling locally, the net profit to the farmer is expected to be 35,000 Egyptian pounds per year for the first ten years of the project. However, if the farmer sells in high profile markets, the net profit can increase to over 100,000 per year. If the farmer does not have enough capital to start the project alone or in collaboration with relatives, there are several options. They can approach a bank and apply for a loan to start the project, or they can approach donor organizations and apply for a grant to finance part of the project. Another option is to combine self-financing with a grant from a funding entity (charity, investors) and a bank loan. GEBAL has prepared detailed business models for greenhouse models and different financing scenarios and has also commissioned an independent feasibility study. Please contact us to view these feasibility studies, to discuss possible nexus farming solutions, and select the best model for your growing conditions.



# A list of the important entities that can help you start your own Water-Energy-Food Nexus project:

- Agricultural Bank of Egypt
- Faisal Islamic Bank
- National Bank of Egypt
- Bank of Alexandria
- Nile Preneur initiative
- Deutsche Gesellschaft für Internationale Zusammenarbeit - GIZ
- CARE Egypt Foundation
- Dandra Development Center
- "Maazara" Contract Farming Company
- Sekem Company
- United Nations Industrial Development Organization - UNIDO
- The United Nations Food and Agriculture Organization – FAO
- Heliopolis University for Sustainable Development - Faculty of Organic Agriculture

# A list of the important entities that can help you start your own Water-Energy-Food Nexus project:

 ALEXBANK | بنك الإسكندرية

  
بنك فيصل الإسلامي المصري  
FAISAL ISLAMIC BANK OF EGYPT

  
البنك الأهلي المصري  
NATIONAL BANK OF EGYPT

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EGYPT  
FOUNDATION

  
البنك الزراعي المصري  
Agricultural Bank of Egypt

  
نيل بريورز  
NilePreneurs

  
جامعة هليوبوليس  
Heliopolis University  
for Sustainable Development

  
منظمة الأغذية والزراعة  
للأمم المتحدة

  
فزارع  
شريك الفلاح

منظمة الأمم المتحدة  
للتنمية الصناعية

  
UNIDO

  
SEKEM

  
مركز دندرة التنموي  
Dandara Development Center

  
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# nexus




**Integrated Agriculture using Water,  
Energy, and Food Nexus, to promote and  
activate comprehensive solutions for  
small and medium-sized farms.**





**Our mission at Gebal is to "achieve sustainable solutions for environmental, agricultural, and livelihood challenges, implement them on the ground, and disseminate them in Egypt and beyond."**

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[www.water-energy-food.org](http://www.water-energy-food.org)

 GEBAL Egypt

 Nexus Platform - The Water,  
Energy & Food Security Resource  
Platform

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 GEBAL Egypt - جبال

 El Heiz Water Education Center