Center of Excellence for Water

WEF Nexus School 2023

Hydroponics and Aquaponics

Dr. Wessam Essam Elssawy

Researcher in AEnRI, ARC, and

Aqua systems Expert in GIZ-NDWMP

Exchange, Training, and Scholarships Pillar activities are implemented in cooperation with:

Agenda

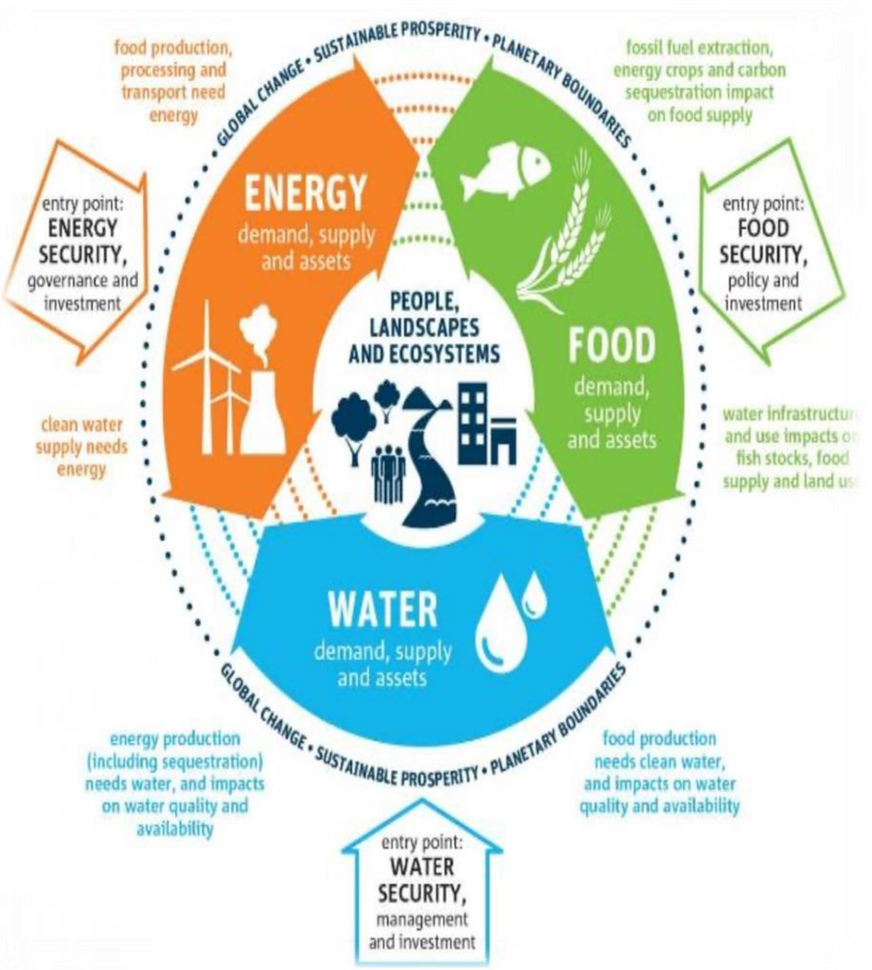
- Introduction and WEF Concept
- Why WEF nexus
- Agriculture and global challenges
- Water in global agriculture
- Agriculture and Food Challenges in Egypt
- Water in global agriculture
- Current state in Egypt
- Differences between Hydroponics, Aquaponic and Soilless culture
- Soilless culture types
- Hydroponics systems types
- Nutrient Film Techniques (NFT)
- Deep Water Culture (DWC)
- Aeroponics
- Wick Hydroponic System
- Ebb and Flow Systems
- Dutch Buckets Systems
- Aquaponics Systems
- General Advantages and Drawbacks
- Substrate Culture
- Nutrient Solution
- The hydroponic systems and WEF nexus
- Substrate culture
- Nutrient Solution
- Devices
- Hydroponic Green Fodder Production
- References
- Some potential sources

Introduction

WEF Nexus Concept:

- The **connections** between **the water, energy, food and ecosystems**, together with the **synergies**, **conflicts** and **trade-offs** that arise from their management (e.g., water for food and food for water,….).

- A ***multicentric lens*** for assessing **integrated resources** management and **sustainable development** in the past decade.



USAID FROM THE AMERICAN PEOPLE

جامعة الإسكندرية ALEXANDRIA UNIVERSITY

The American University in Cairo

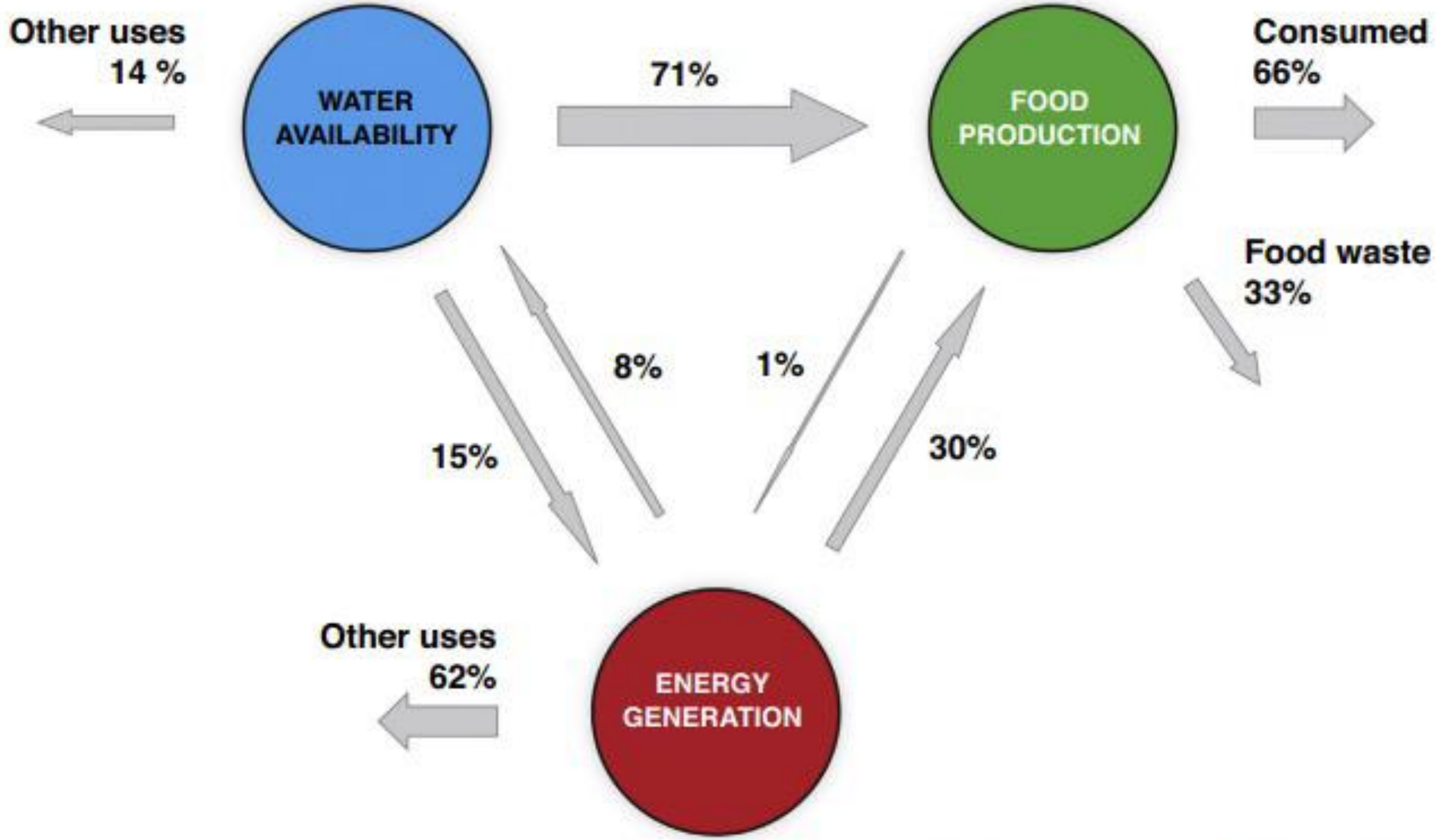
Why WEF nexus? Two key pieces in my mind:

- Trade-offs in use of the resources (including biophysical and social economic factors) with a transdisciplinary approach
- Governance and policy coherence; decisionmakers needs

USAID FROM THE AMERICAN PEOPLE

جامعة الإسكندرية ALEXANDRIA UNIVERSITY

The American University in Cairo



Current Opinion in Environmental Sustainability

USAID FROM THE AMERICAN PEOPLE

جامعة الإسكندرية ALEXANDRIA UNIVERSITY

The American University in Cairo

Agriculture is central to global challenges – Its all about feeding people

- By 2030 humankind will need 30% more water, 40% more energy and 10% of existing crop land for biofuels
- By 2050 Population: 10 billion despite 7.7 billion now.
- **Only 25% more?!**

➢ But need 50-100% more food production

➢ 570 million farms worldwide - 75% small farms on less than 2 ha.

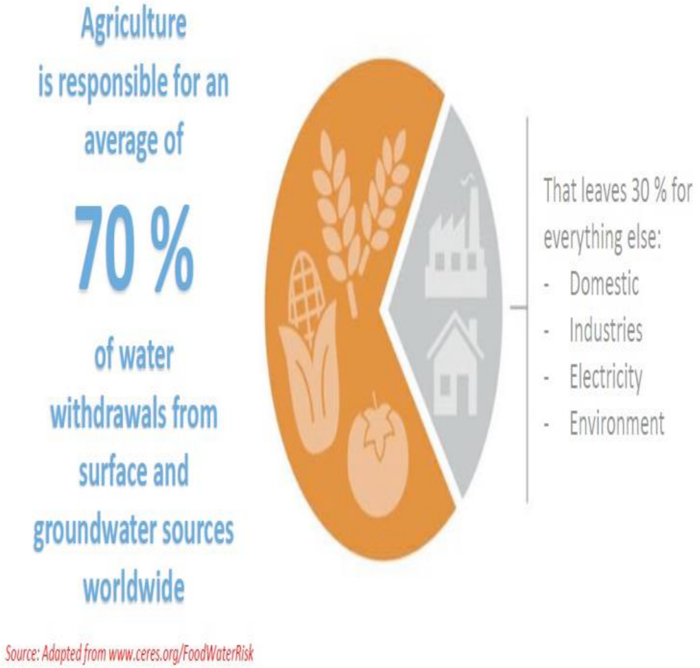
➢ Waste and Loss.

Water in global agriculture:

- Global Efficiency is 33%.

- 50% global consumption lost.

- Tackling these challenges and devising sustainable solutions is of utmost importance in order to establish a resilient and inclusive food system capable of meeting the demands.



Current state in Egypt

- Egypt, known for its abundant agricultural legacy, has historically served as a significant source of food for the Middle East.

- The agricultural sector consumes 85 % water resources.

- Egypt uses 127% of its water resources, in which 27% of the water used is virtual water.

These challenges are further compounded by the compounding factors of rapid population growth, water scarcity, land degradation, climate change, and socio-economic disparities.

USAID FROM THE AMERICAN PEOPLE

جامعة الإسكندرية ALEXANDRIA UNIVERSITY

The American University in Cairo

Center of Excellence for Water - Exchange, Training, and Scholarships

- After all pervious challenges, there is a severe need to increase the agricultural productivity, save water and in Egypt using the available resources, which requires new solutions for the challenges facing water scarcity and **achieving sustainable agriculture in Egypt such as soilless culture, hydroponic and aquaponic**

Difference between hydroponics, aquaponic and soilless culture

- Soilless culture can be defined as “any method of growing plants without the use of soil as a rooting medium, in which the inorganic nutrients absorbed by the roots are supplied via the irrigation water”.

Soilless culture is a huge umbrella, it is usually classified according to the type of plant support as:

1- Substrate culture (Sand, Gravel, Perlite, Peatmoss, etc.)

2- Water culture or **hydroponic** (NFT, DWC, Aeroponics,etc.) and all of them can be **Aquaponics**

Soilless culture can be divided as:

Water culture (Hydroponics)	Substrate culture
Nutrient film technique	Gravel media
Deep water culture	Sand-ponic
Aeroponics	Peatmoss media
Wick system	Perlite media
Ebb and flow system	Coconut media
Dutch Backet water culture	Dutch Backet substrate culture

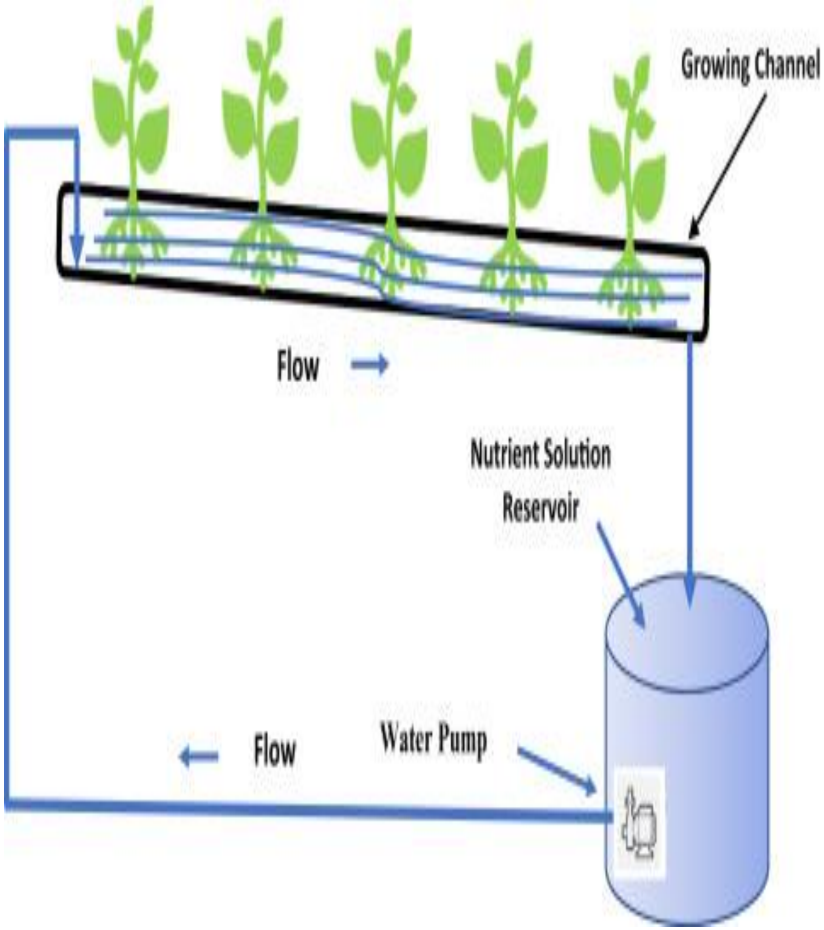
Hydroponics systems?

Hydroponics is a modern agricultural technique that allows plants to be cultivated without relying on conventional soil. Instead, plants are grown in nutrient solutions or inert growing media, providing them with the essential elements for growth and development

Hydroponics systems

1- The Nutrient Film Technique (NFT)

Construction and Crops of NFT



Advantages of Nutrient Film Technique (NFT):

- Water Efficiency
- Nutrient Control
- Space Efficiency
- Reduced Pest and Disease Issues
- Higher Yields

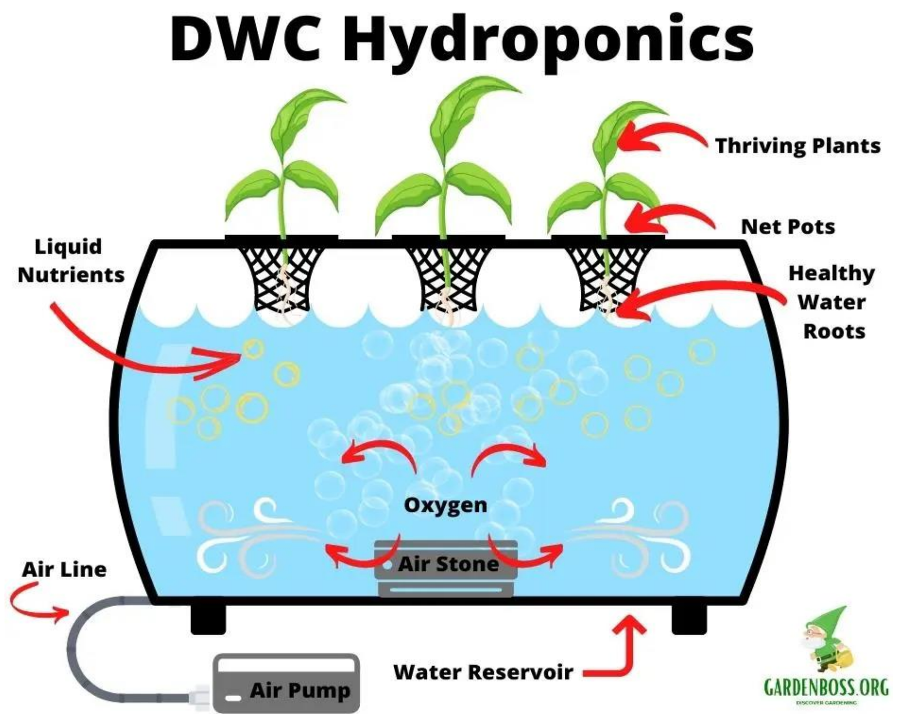
Disadvantages:

- Susceptibility to System Failures
- Root Health
- Maintenance and Monitoring
- Initial Setup Cost
- Skill and Expertise

USAID FROM THE AMERICAN PEOPLE | جامعة الإسكندرية ALEXANDRIA UNIVERSITY | The American University in Cairo

2- Deep Water Culture (DWC)

Construction and Crops of DWC



Deep Water Culture (DWC):

Advantages:

- Simplicity and Low Cost.
- Excellent Oxygen Availability
- Water and nutrients Efficiency

Disadvantages:

- Potential for Root Diseases
- Power Dependence
- Space needs Vs NFT

USAID FROM THE AMERICAN PEOPLE

جامعة الإسكندرية ALEXANDRIA UNIVERSITY

The American University in Cairo

Center of Excellence for Water - Exchange, Training, and Scholarships

3- Aeroponics:

USAID
FROM THE AMERICAN PEOPLE

جامعة الإسكندرية
ALEXANDRIA UNIVERSITY

The American University in Cairo

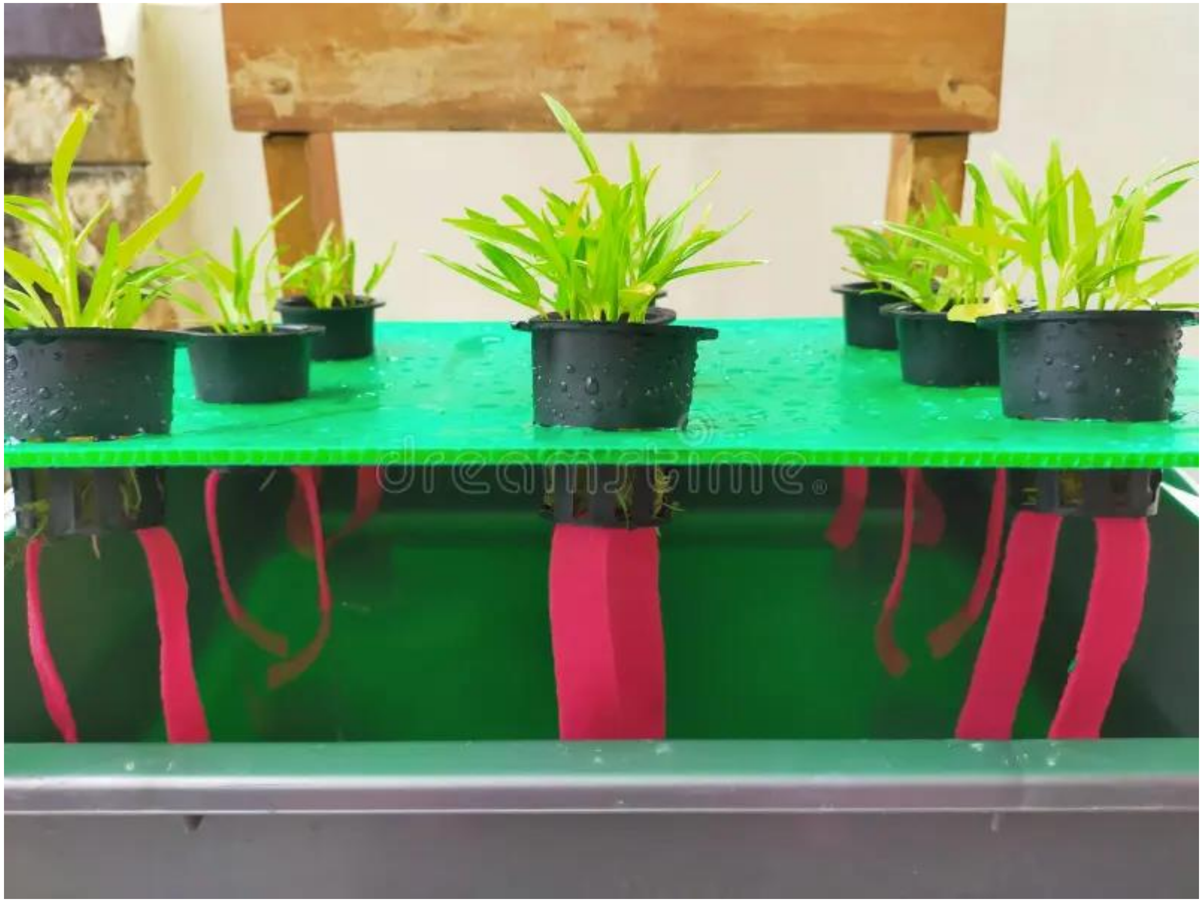
Construction and crops of Aeroponics

Advantages of Aeroponics:

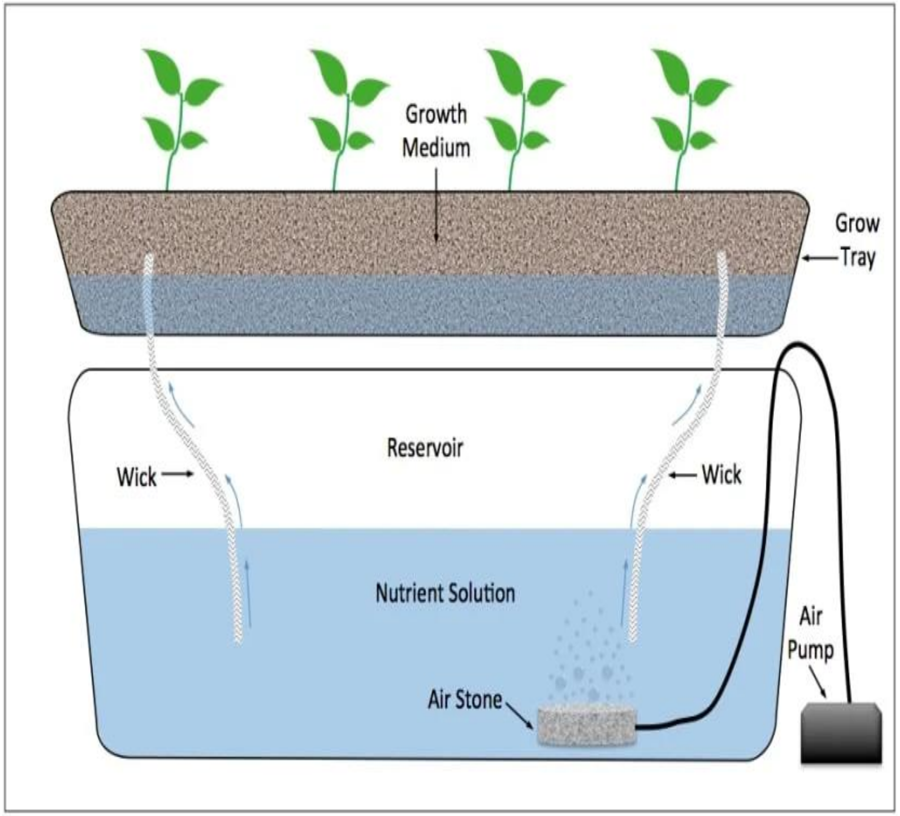
- Excellent Nutrient Delivery
- Water Efficiency
- Space Efficiency

- **Disadvantages**
- Technical Expertise Required
- Risk of System Failures

4- The Wick Hydroponic System (WHS)



Construction and crops of WHS



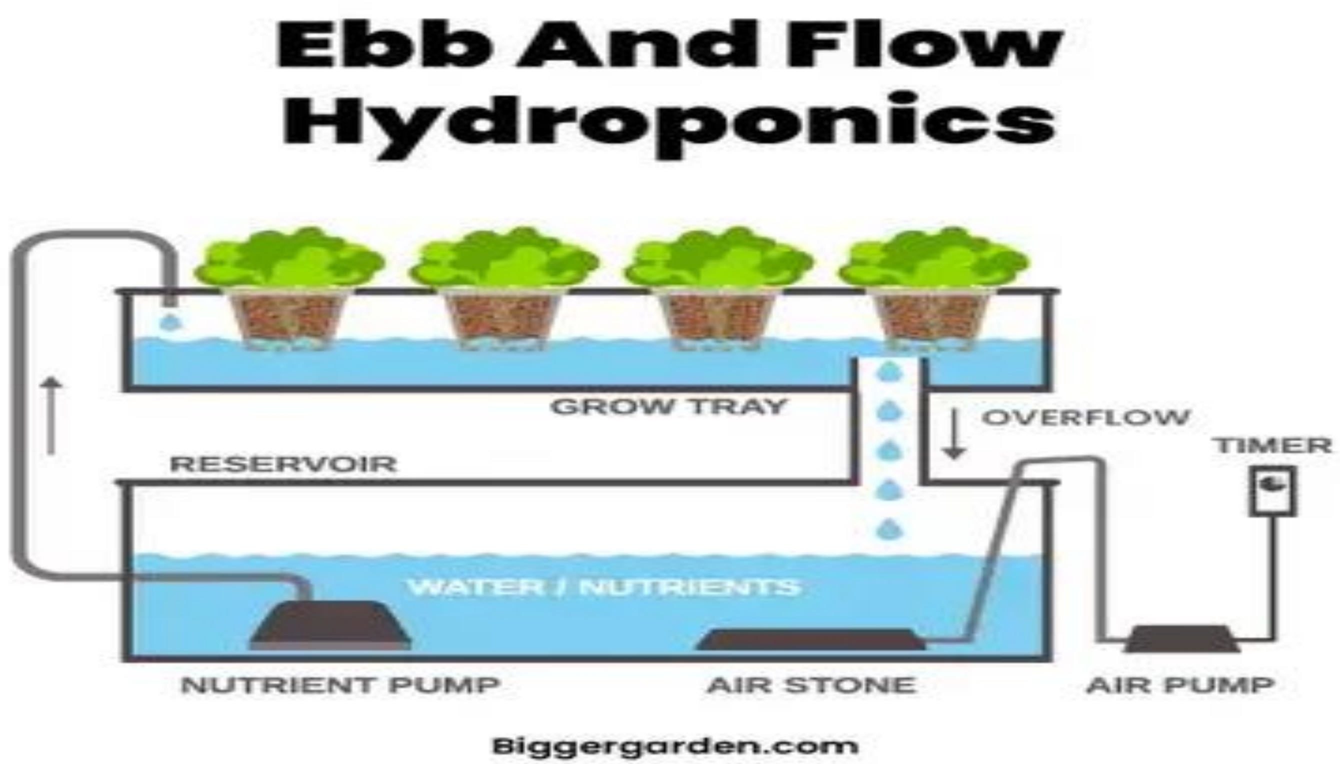
Advantages of WHS

- Simplicity
- Low Cost
- Suitable for Small Plants
- Energy-Efficient

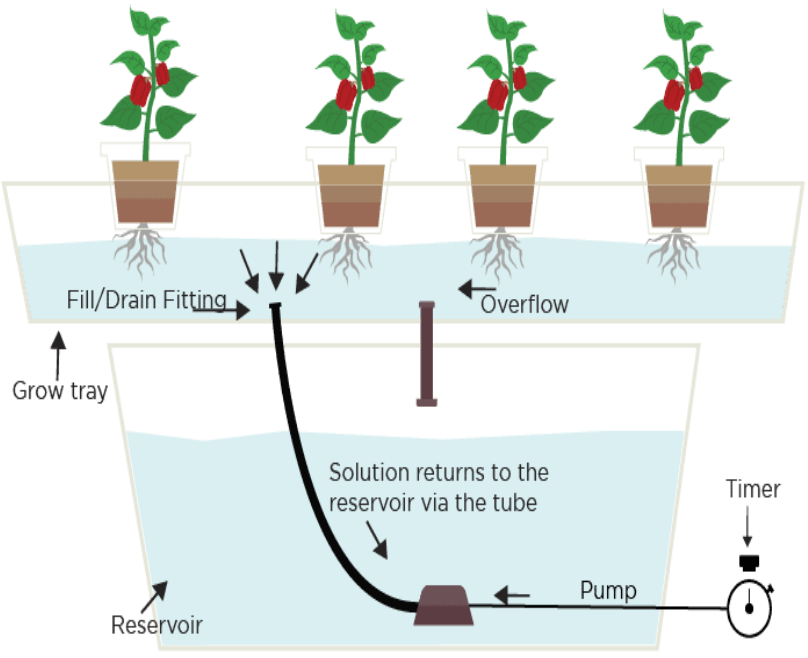
Disadvantages of WHS

- Limited to Small Plants
- Slow Growth
- Risk of Overwatering or Underwatering
- Nutrient Imbalance

5 - The Ebb and Flow system (Ebb)



Construction and crops of Ebb and flow



Advantages of Ebb and Flow system

1- Oxygenation of Roots

2- Nutrient Uptake

3- Reduced Risk of Overfeeding

4- Root Health

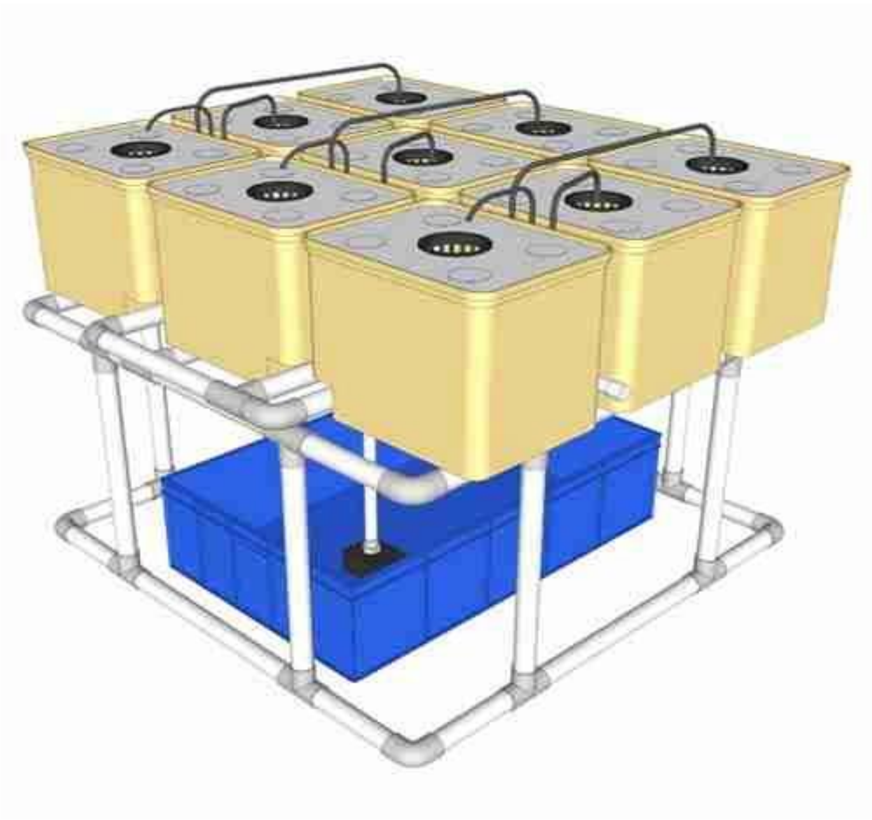
Disadvantages of Ebb and Flow system

1. Complex Setup
2. Maintenance
3. Risk of System Failures
4. Resource Intensive

USAID FROM THE AMERICAN PEOPLE
جامعة الإسكندرية ALEXANDRIA UNIVERSITY
The American University in Cairo

6 - Dutch buckets hydroponics system (DB)

Construction and Crops of DB



Dutch buckets hydroponics advantages

- **Individual Plant Control**
- **High Yield**
- **Improved Oxygenation**
- **Reduced Pest and Disease Risk**
- **Flexibility of grown plant**
- **Easy Monitoring and Maintenance**

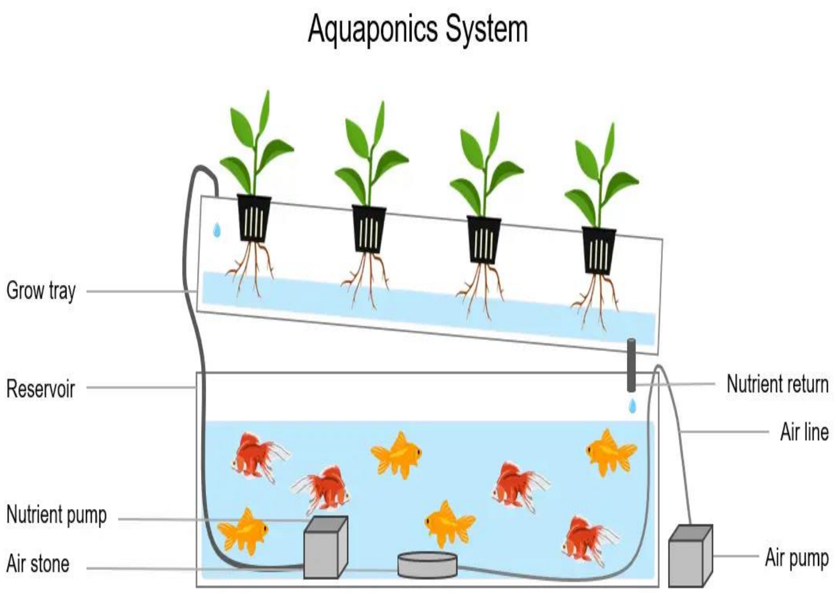
Disadvantages:

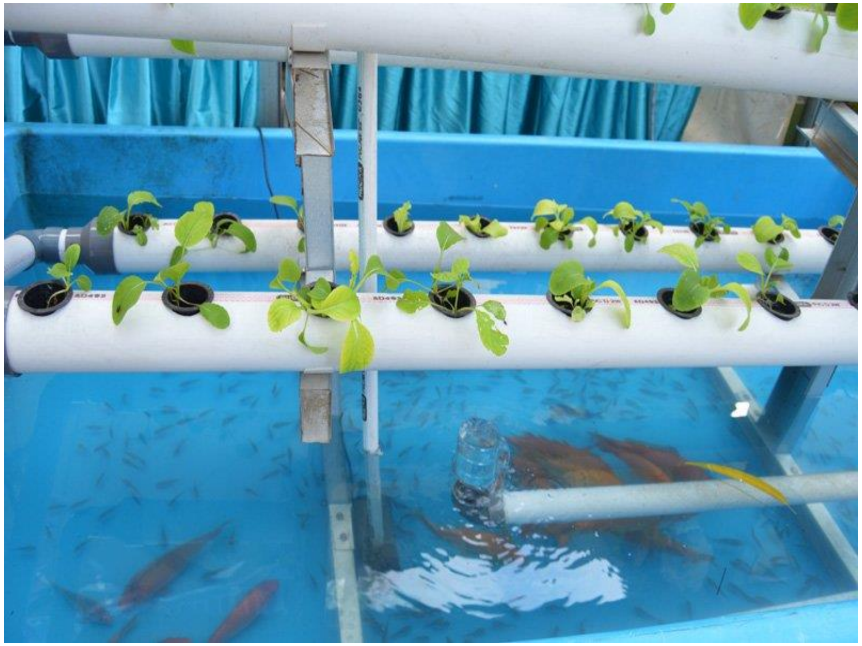
- **Complex Setup**
- **Resource Intensive**
- **Initial and Maintenance cost**

7- Aquaponics as An Environmentally Friendly Farming System

- Aquaponics represents an innovative and sustainable farming technique that merges **aquaculture** (fish farming) with any **hydroponics system**.
- This unique symbiotic system creates a closed-loop ecosystem where fish and plants coexist, benefiting from each other's presence.

Construction, How Aquaponics Works crops of Aquaponics





Aquaponics systems

Advantages

1. Resource Efficiency
2. Organic and Chemical-Free Produce
3. Faster Growth and Higher Yields
4. Space Efficiency
5. Environmental Benefits
6. Year-Round Production

Disadvantages of Aquaponics:

1. Initial Setup Cost
2. Technical Knowledge
3. System Complexity
4. Dependence on Electricity

Careful consideration of crop selection is necessary to ensure successful cultivation.

General Advantages of all Hydroponic and aquaponic systems:

- ✓ Water Efficiency
- ✓ Nutrient Control
- ✓ Faster Growth Rates and Increased Yields
- ✓ Space Efficiency
- ✓ Reduced Environmental Impact
- ✓ Year-Round Production:
- ✓ Crop Diversity and Specialty Crops
- ✓ Pest and Disease Control

Drawbacks of Hydroponic Systems

1. Initial Cost
2. Technical Knowledge and Expertise
3. Monitoring and Maintenance
4. Power Dependence
6. Crop Selection

The relationship between hydroponic systems and WEF nexus

- ✓ Hydroponic system aligns with the objectives of the WEF nexus and provides several benefits.

- ✓ Water: Hydroponic systems are recognized for their water efficiency, offering significant reductions in water consumption compared to traditional soil-based agriculture.

- ✓ Energy: Hydroponic systems contribute to energy efficiency by creating optimal growth conditions for plants, including controlled light, temperature, and humidity.

- ✓ Food: Hydroponic systems have the potential to increase food production and enhance food security, hydroponics promote faster growth rates and higher yields.

Substrate culture

Center of Excellence for Water - Exchange, Training, and Scholarships

Nutrient Solution

Macronutrients	Concentrations in ppm	
	Vegetative growth stage	Flowering or fruiting stage
Nitrogen (N)	100 to 200	80 to 150
Phosphorus (P)	30 to 50	30 to 50
Potassium (K)	150 to 250	150 to 250

Secondary Nutrients	Concentrations in ppm
Calcium (Ca)	150 to 200
Magnesium (Mg)	30 to 50
Sulfur (S)	20 to 40

Micronutrients (Trace Elements)	Concentrations in ppm
Iron (Fe)	1.0 to 5.0
Manganese (Mn)	0.5 to 2.0
Zinc (Zn)	0.5 to 2.0
Copper (Cu)	0.05 to 0.1
Boron (B)	0.5 to 1.0
Molybdenum (Mo)	0.01 to 0.05
Nickel (Ni)	Around 0.01

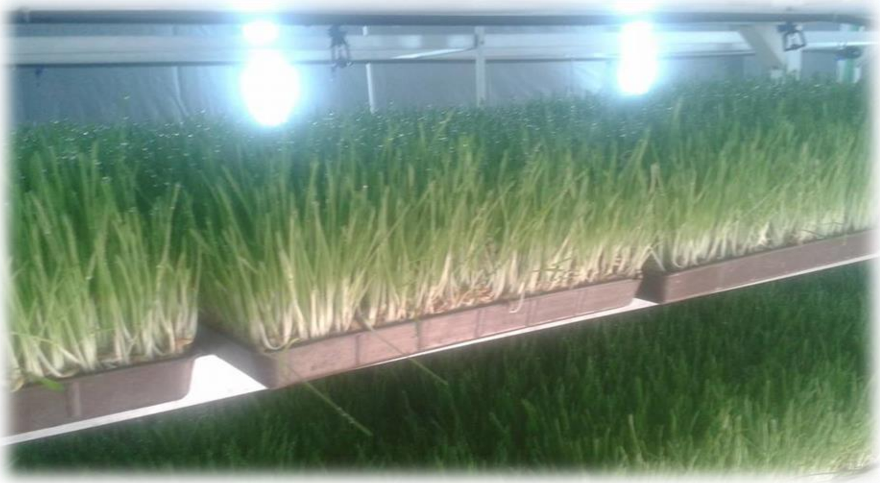
Devices

pH

D.O.

E.C

Hydroponic Green Fodder Production



Center of Excellence for Water - Exchange, Training, and Scholarships

References

Abdel-Ghany, T., et al. (2016). Enhancing Agricultural Research and Innovation Systems in Egypt. Journal of Agricultural Extension and Rural Development, 8(10), 244-252.

Abdelhamid, M., Youssef, M., & Morsy, A. (2017). Nile River water scarcity: Challenges and opportunities for future water management. Journal of Hydrology: Regional Studies, 13, 85-101.

Climate Change Adaptation in the Agriculture Sector in Egypt. (2019). Food and Agriculture Organization (FAO).

Egypt's Sustainable Agricultural Development Strategy towards 2030. (2016). Ministry of Agriculture and Land Reclamation.

Eissa, M. F., et al. (2020). Integrated Pest Management in Egypt: Current Status, Challenges, and Opportunities. In Integrated Pest Management (pp. 15-37). Springer, Cham.

El-Dessougi, H., et al. (2018). Agricultural Research and Innovation in Egypt: Current Status, Constraints, and Opportunities. International Journal of Agricultural Science, Research and Technology in Extension and Education Systems, 8(1), 55-65.

El-Haggar, S. M., & El-Zoghby, M. A. (2018). The role of urban agriculture in enhancing food security in Egypt. Acta Hortic, 1201, 295-302.

El-Keblawy, A., & Sheded, M. G. (2018). Climate change and its potential impacts on agriculture in Egypt. Regional Environmental Change, 18(7), 1931-1941.

El-Sayed, M., et al. (2021). Agricultural Research and Innovation in Egypt: Challenges and Opportunities. Agriculture, 11(6), 537.

El-Shakhs, S. A., & El-Enany, M. H. (2020). Land use planning to face urban sprawl and agricultural land conversion in Egypt. Environmental Science and Pollution Research, 27(2), 1663-1684.

El-Sharkawy, M. A., et al. (2019). Sustainable intensification of agriculture in Egypt: Challenges and prospects. Agronomy, 9(4), 169.

Food and Agriculture Organization (FAO). (2018). Country fact sheet on food and agriculture policy trends: Egypt. Retrieved from http://www.fao.org/3/i8575e/I8575E.pdf

Gomaa, N. H., et al. (2019). Integrated Pest Management in Egypt: Challenges and Prospects. Journal of Plant Protection Research, 59(4), 469-483.

Hussein, H. A., et al. (2017). Plant breeding and genetic engineering for pest and disease resistance in crops: Challenges and strategies. Insect Science, 24(6), 990-1017.

Ibrahim, M. M., et al. (2020). Impact of Climate Change on the Agriculture Sector in Egypt. Environment, Development and Sustainability, 22, 1847-1871.

Jensen, M. H. (1997). Hydroponics: A Practical Guide for the Soilless Grower. CRC Press.

Khan, M. I., Dastane, N. G., Parveen, R., & Adil, M. (2019). Hydroponics: A Step Towards Sustainable Agriculture. International Journal of Advanced Research in Engineering, Science and Technology, 6(2), 139-144.

Li, Y., & Papadopoulos, A. P. (2012). Vertical farming systems and components. Acta Horticulturae, 927, 47-56.

Parveen, R., Dastane, N. G., Khan, M. I., & Adil, M. (2020). Urban Hydroponics: A Sustainable Approach for Food Security. International Journal of Advanced Research in Engineering, Science and Technology, 7(3), 171-175.

Raviv, M., Medina, S., & Krasnovsky, A. (2018). Soilless Culture and Its Environmental Impact. In Soilless Culture: Theory and Practice (pp. 623-669). Academic Press.

Resh, H. M. (2013). Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower. CRC Press.

Rouphael, Y., Colla, G., & Giordano, M. (2017). Innovative Solutions for Sustainable Agriculture: The Contribution of Soilless Culture Systems. In Soilless Culture (pp. 461-504). Springer.

Sasek, T. W., & Strain, H. H. (1988). Hydroponics. In The Science of Horticulture (pp. 641-675). Wiley.

Savvas, D., & Passam, H. C. (2017). Hydroponic production of vegetables and ornamentals. CRC Press.

Shehata, E. M., et al. (2019). Climate change adaptation strategies for agriculture in Egypt: A review. Journal of Soil Science and Plant Nutrition, 19(1), 1-16.

Tyagi, S., & Goyal, A. (2020). Hydroponics: The Future of Sustainable Agriculture. In Handbook of Sustainable Agriculture (pp. 471-495). Springer.

Tyson, R. V., Durner, E. F., & Crofcheck, C. L. (2019). Hydroponic Tomatoes: A Comprehensive Guide for the Successful Production of Quality Fruit. CRC Press.

Some potential sources to explore for further information

1. Food and Agriculture Organization of the United Nations (FAO) - www.fao.org
2. International Water Management Institute (IWMI) - www.iwmi.org
3. United Nations Development Programme (UNDP) - www.undp.org
4. Ministry of Agriculture and Land Reclamation in Egypt - www.agr.gov.eg
5. Ministry of Water Resources and Irrigation (MWRI) - Egyptian ministry responsible for managing water resources and irrigation. Website: http://mwri.gov.eg/
6. Food and Agriculture Organization (FAO) - United Nations agency specializing in agriculture, food, and water management. Website: http://www.fao.org/egypt/en/
7. World Bank - International financial institution that provides data and reports on various topics, including water management. Website: http://www.worldbank.org/

Center of Excellence for Water Partners:

This presentation is made possible by the support of the American People through the United States Agency for International Development (USAID.) The contents of this presentation are the sole responsibility of the Center of Excellence for Water and do not necessarily reflect the views of USAID or the United States Government.


Thank
you !