AWESOME

WATER-ECOSYSTEM-FOOD

IMPACT AND CAPACITY DEVELOPMENT

October, 2023

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LIST OF ACRONYMS

Abbreviations

CS: Case Study
DM: Deliverable Manager
EC: European Commission
Mx: Month number
PC: Project Coordinator
RP: Reporting Period
WP: Work Package

EXECUTIVE SUMMARY

This document reports on Deliverable 6.3 - Impact and Capacity Development (Demonstration) and describes the preparation and delivery of the associated Training Workshop which was held on 25/10/2023. It provides a description of the skills gap assessment of stakeholders' knowledge and training needs, the results of the survey, the training session and material, as well as recommendations to maximize the technological uptake of the soilless agriculture.

Nexus knowledge development and transfer, as information related to the system's natural and socio-economic interactions, is crucial in project-oriented climate research and case studies. In AWESOME project the Nexus knowledge developed in the demo site can be used for the purpose of the soilless technology uptake for a wide range of actors.

In order to strengthen the technological uptake the project recognises the importance of needs-based capacity development. A survey was developed and implemented by AEUB and ZG teams in order to assess the existing capacities as well as capacity development needs and knowledge gaps. On that basis, a more concrete training plan was constructed based on the survey results with the collaboration of the RWTH Aachen University partners. The Skills Gap Assessment Questionnaires (SGAQ) targeted agricultural engineers, financiers and general stakeholders.

The resulting training material is part of ANNEX I, while the recommendations for maximizing technological uptake focus on the need to deal with the high installation costs, with the low awareness of practitioners that mainly rely on transferred technologies that are not scientifically sound, as well as the need for governmental support.

ANNEX II includes the methods and the results from the Participatory Narratives Building Workshop that took place with meso level stakeholders in June 2023 in collaboration with WP4 and the reported in D4.3 Efficient WEF Planning Portfolios. Future narratives are qualitative storylines that capture a future vision for the case study area and portray a visionary image of the site in a future where the various sectors work together to enhance WEFE synergies. In that workshop, the stakeholders explored the state of the key drivers in the context of future trends and built storylines around them. The activities that took place during the workshop attempted to inspire the participants and mobilize them to develop shared narratives along with the project's researchers.

1. INTRODUCTION

Nexus knowledge development and transfer, as information related to the system's natural and socio-economic interactions, is crucial in project-oriented climate research and case studies. In AWESOME project the Nexus knowledge developed in the demo site can be used for the purpose of the soilless technology uptake for a wide range of actors. The project has built a baseline knowledge of the Nexus based on an integrated approach achieving multi-disciplinarity for multi-system problem solving. That knowledge baseline which deals with multiple sectors trade-offs is not only a good first step for new practitioners. For the students incorporating the nexus approach can provide them with the opportunity to enrich their knowledge portfolio and to provide consolidation with an innovative case study application or even to bridge knowledge gaps to be able to interact with other disciplines. It is necessary for specialists as well who are interested to learn communicating with cross-sectoral actors and disseminate the nexus approach and the soilless agriculture benefits within their organization and networks.

The type of knowledge transfer that was chosen was the one-day Training clearly structured and goal-oriented with the learning instructed by the project's scientists. Transferring knowledge from the findings of the project's experiments in a way that directly contributes to local capacity development at a cross- sectoral and network level. The main purpose of the training workshop was to build capacity among key stakeholders with the aim of promoting development and application of aquaponic, sandponic, hydroponic techniques in the Nile River Basin. In this way, the project seeks to maximise the impact of it's research outputs in a context that is directly relevant to the learning-needs of key stakeholders.

1.1 Limitations and Mitigation

While the training workshop was initially planned to take place in- person, in Cairo on the 25th of October 2023, the geo-political instability within the region posed several risks (safety, travel, access, availability of participants). As such, an extraordinary decision was reached between the AUEB and ZG teams, with the approval of the project coordinator, Andrea Castelletti, to move the training online as a mitigation measure. The consequent trade-off of the decision, being reduced engagement with farmers and other agricultural workers who either do not have or are unable to access a strong internet connection.

2. METHODOLOGY

2.1 Gaps and Needs Assessment

In order to strengthen the technological uptake AUEB and ZG partners recognised the importance of needs-based capacity development. A survey was developed by the team aiming at participatory assessment of the existing capacities as well as capacity development needs and knowledge gaps. On that basis, a more concrete training material was constructed based on the survey results with the collaboration of the RWTH Aachen University partners. The survey focused both on soft skills as well as theoretical and practical knowledge and education needs and targeted the main beneficiaries of the soilless agriculture technology: agricultural engineers, financiers and investors, and general stakeholders.

Separate Skills Gap Assessment Questionnaires (SGAQ) were created for different stakeholder groups: one targeting agricultural engineers, and one targeting financiers and general stakeholders.

Questionnaires were made up of two parts, with the first addressing individual professional aspects such as education level or challenges people face in the agricultural sector and the second part focusing on self-assessment of knowledge. There were no right or wrong questions and the only prerequisite for participating was the participants were able to understand the context and the questions.

3. SKILLS GAP ASSESSMENT

3.1 SKILLS GAP ASSESSMENT QUESTIONNAIRES

The following sections present the questionnaires along with their results

3.1.1 Skills Gap Assessment Questionnaire for agricultural engineers

This Skills Gap Assessment Questionnaire (SGAQ) is designed to capture your skills and identify your capacity building needs. The overall purpose of this assessment is to develop accordingly training workshops in order to ensure that the soilless agriculture technology tested in AWESOME project will have the maximum uptake.

1. Complete your email

<u>INDIVIDUAL FARM LEVEL DATA</u>

2. What is your age?

o Below 20

o 20 - 30

o 30 - 40

o 40 - 50

o 50 - 60

3. What is your education level?

o Vocational school or technical college

o Elementary education High school education Graduate Postgraduate

4. Is your education relative to agricultural engineering?

o Yes

o No

5. What is your gender?

- o Female
- o Male
- o Prefer not to say

6. Do you have links with
   - Other stakeholders
   - Public institutions
   - Information channels
   - Benefits from extension services

7. Where do you mostly get your information to support your activities?

- o Personal experience
- o Agriculture associations
- o Community
- o Programs and shows
- o Internet

8. Which tools do you currently use to support your activities?
   - Weather data forecast?
   - You own weather station?
   - Smartphones?
   - Computers?
   - Traditional knowledge?
   - Field observations?

9. What are the main issues/challenges you see in the agricultural sector?

- o Cost of fertilizers and pesticides
- o Availability and accessibility of fertilizers and pesticides
- o Know how on best practices
- o Access to market
- o Cost of production
- o Sale prices
- o Other

DATA ON YOUR SKILLS AND KNOWLEDGE

10. Rate your knowledge on crop protection and fertilization

- No knowledge
- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

11. Rate your knowledge on your access to market

- No knowledge
- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

12. Rate your knowledge on hydroponics, aquaponics, sandponics technology

- No knowledge
- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

13. Rate your knowledge on Water-Energy-Food-Ecosystems Nexus

- No knowledge
- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

3.1.2 Skills Gap Assessment Questionnaire for general public and financiers

This Skills Gap Assessment Questionnaire (SGAQ) is designed to capture your skills and identify your capacity building needs. The overall purpose of this assessment is to develop accordingly training workshops in order to ensure that the soilless agriculture technology tested in AWESOME project will have the maximum uptake by micro level farmers and small-holders.

1. Complete your email

INDIVIDUAL FARM LEVEL DATA

2. What is your age?

o Below 20

o 20 - 30

o 30 - 40

o 40 - 50

o 50 - 60

3. What is your education level?

o Vocational school or technical college

o Elementary education High school education Graduate Postgraduate

4. Is your education relative to agricultural engineering?

o Yes

o No

5. What is your gender?

o Female

o Male

o Prefer not to say

6. What is your profession

…

7. Do you have links with

o Other stakeholders

- Public institutions
- Information channels
- Benefits from extension services

8. Where do you mostly get your information to support your activities?

- Personal experience
- Agriculture associations
- Community
- Programs and shows
- Internet

9. Which tools do you currently use to support your activities?

- Weather data forecast?
- You own weather station?
- Smartphones?
- Computers?
- Traditional knowledge?
- Field observations?

10. What are the main issues/challenges you see in the agricultural sector?

- Cost of fertilizers and pesticides
- Availability and accessibility of fertilizers and pesticides
- Know how on best practices
- Access to market
- Cost of production
- Sale prices
- Other

DATA ON YOUR SKILLS AND KNOWLEDGE

11. Rate your knowledge on crop protection and fertilization

- No knowledge

- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

12. Rate your knowledge on your access to market

- No knowledge
- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

13. Rate your knowledge on hydroponics, aquaponics, sandponics technology

- No knowledge
- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

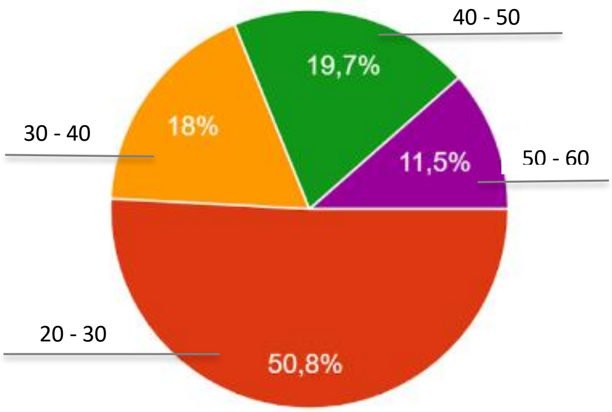
14. Rate your knowledge on Water-Energy-Food-Ecosystems Nexus

- No knowledge
- Little knowledge
- Some/average knowledge
- Good knowledge
- Very good knowledge

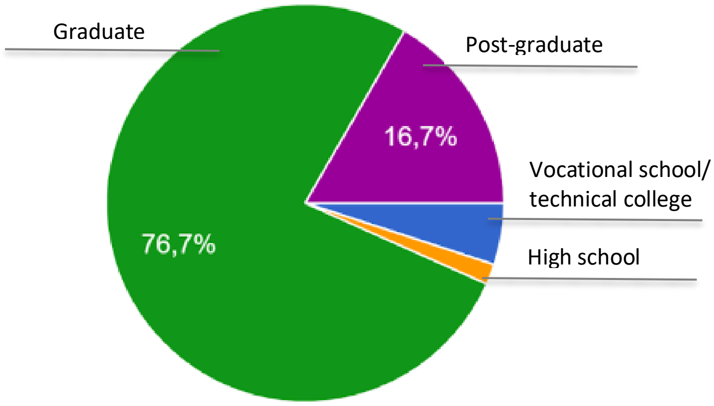
3.2 Survey results

3.2.1 Results for agricultural engineers

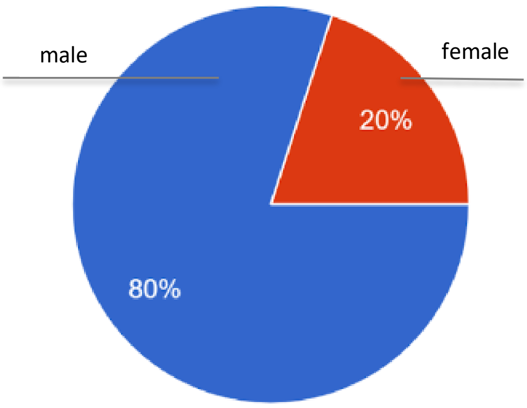
What is your age?



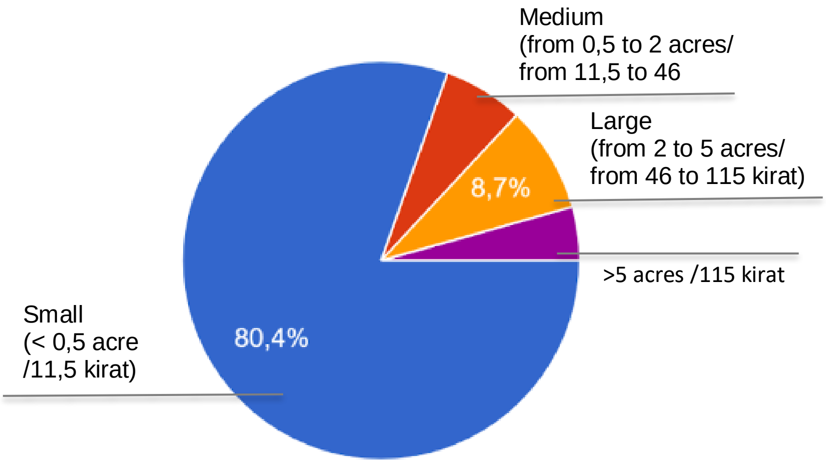
What is your educational level?



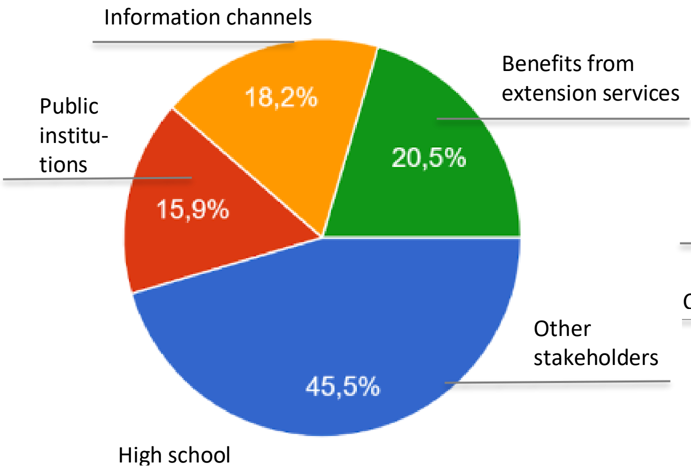
What is your gender?



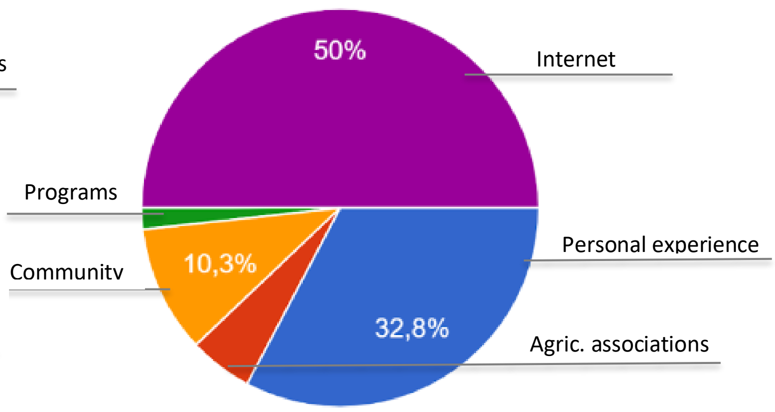
What is the size of your farm?



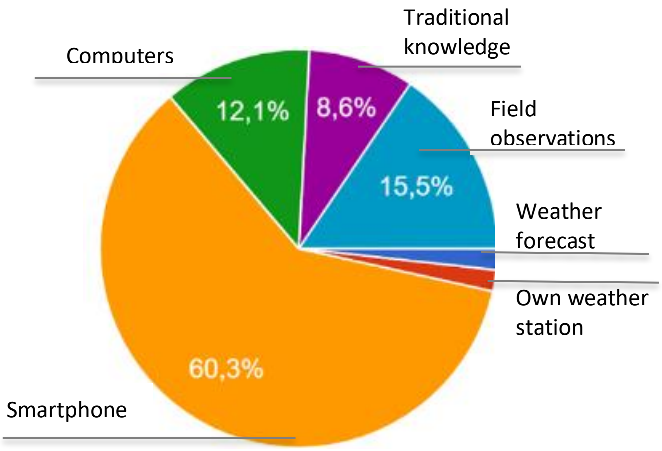
Do you have links with?



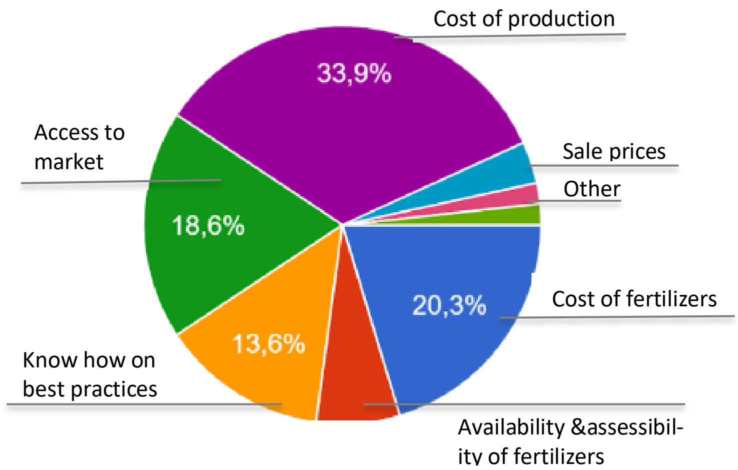
Where do you mostly get information to support your activities?



What tools do you use to support your activities?

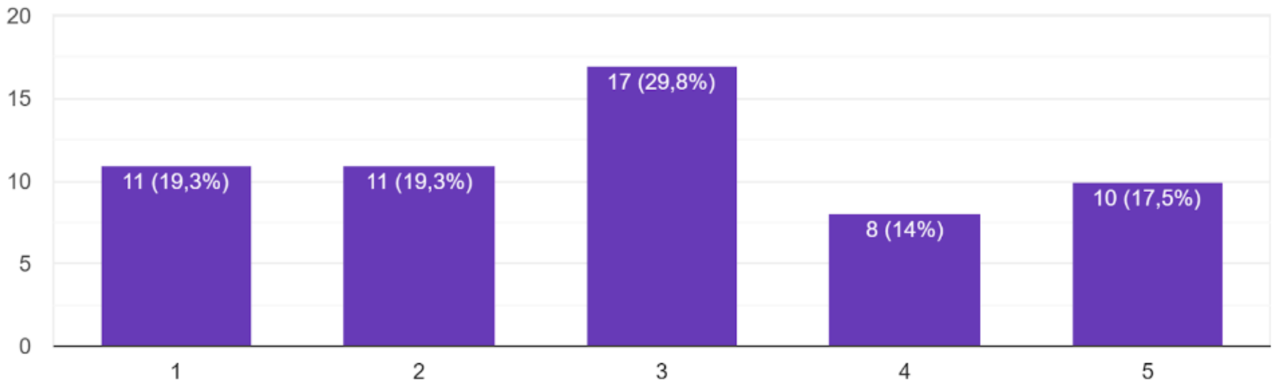


What are the main challenges in the agriculture?



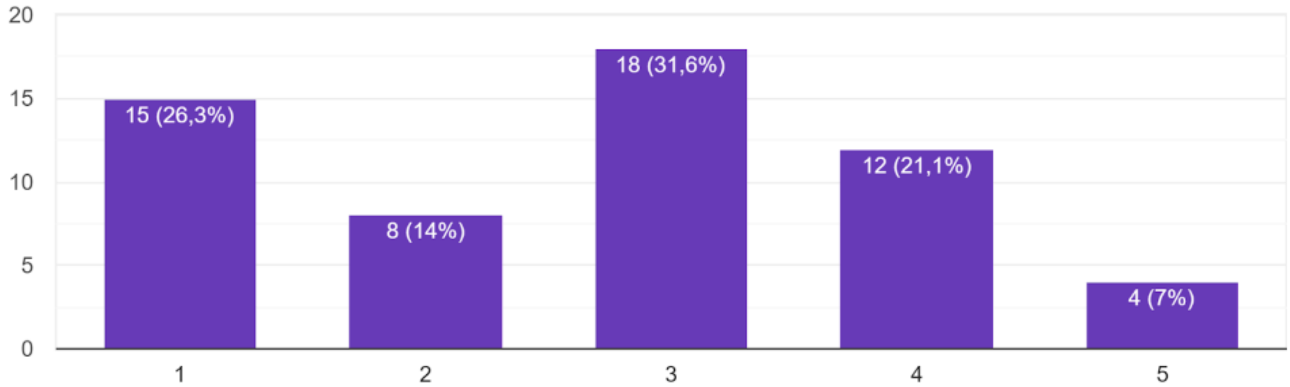
DATA ON YOUR SKILLS AND KNOWLEDGE

Rate your knowledge on crop protection and fertilization



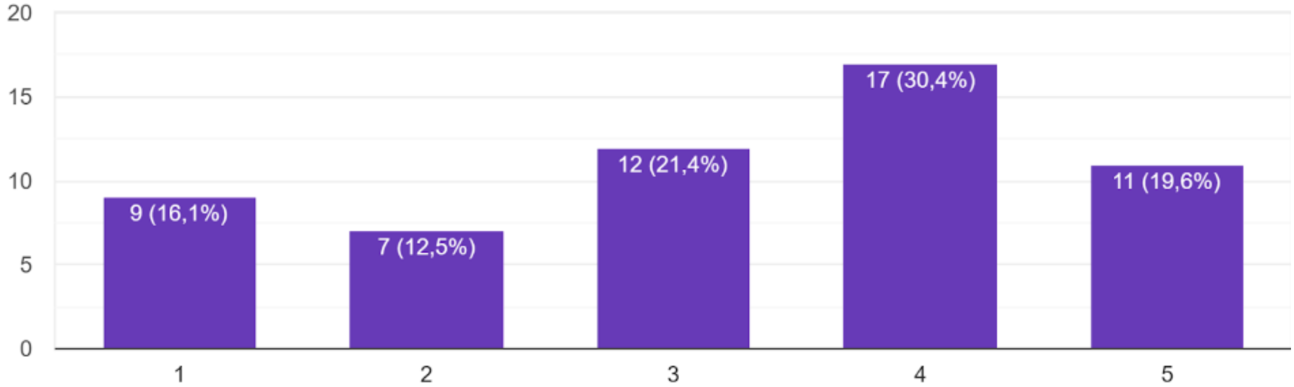
No knowledge | Little knowledge | Some/average knowledge | Good knowledge | Very good knowledge

Rate your knowledge on your access to market



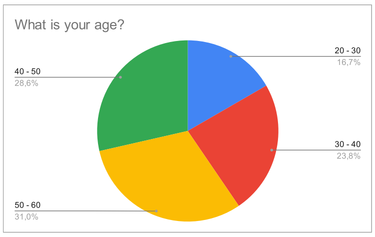
No knowledge | Little knowledge | Some/average knowledge | Good knowledge | Very good knowledge

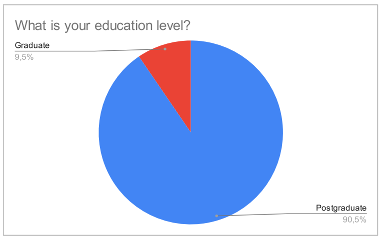
Rate your knowledge on Water-Energy-Food-Ecosystems Nexus

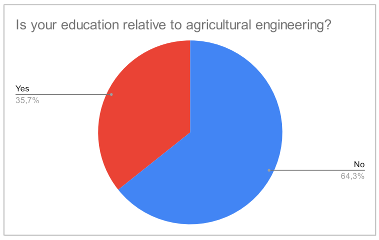


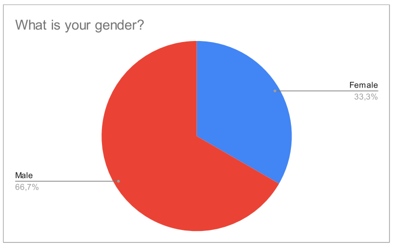
No knowledge	Little knowledge	Some/average knowledge	Good knowledge	Very good knowledge

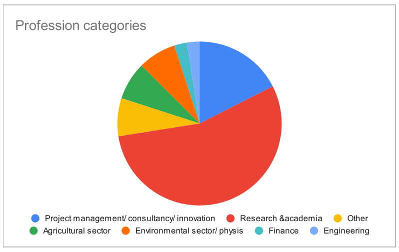
3.2.2. Results for general public and financiers

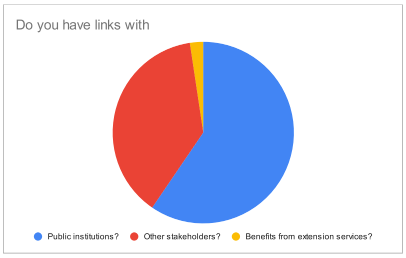

What is your age?
20 - 30
16,7%
40 - 50
28,6%
30 - 40
23,8%
50 - 60
31,0%

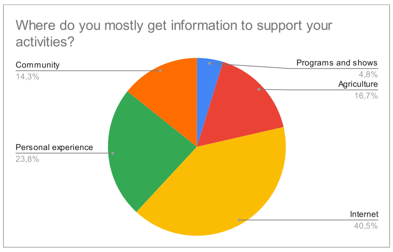

What is your education level?
Graduate
9,5%
Postgraduate
90,5%

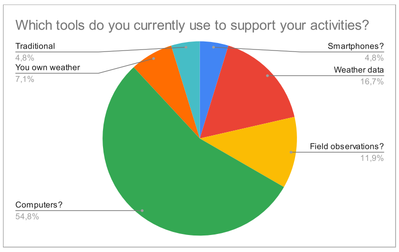

Is your education relative to agricultural engineering?
Yes
35,7%
No
64,3%

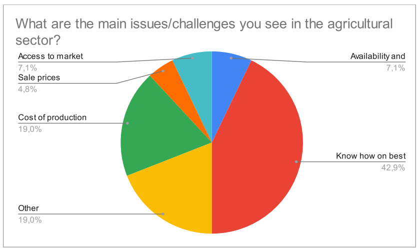

What is your gender?
Female
33,3%
Male
66,7%

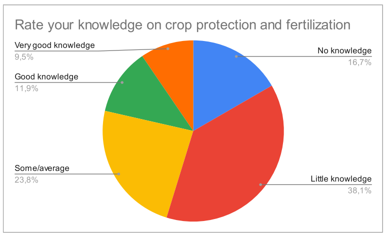

Profession categories
Project management/ consultancy/ innovation
Research &academia
Other
Agricultural sector
Environmental sector/ physis
Finance
Engineering

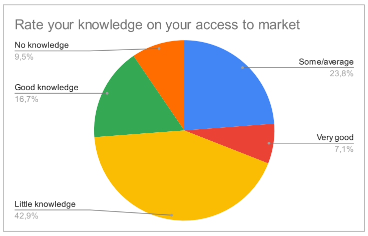

Do you have links with
Public institutions?
Other stakeholders?
Benefits from extension services?

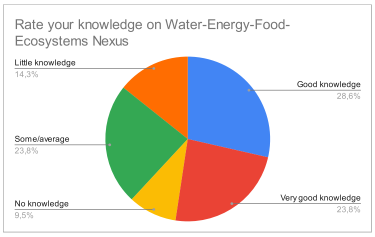

Where do you mostly get information to support your activities?
Community
14,3%
Programs and shows
4,8%
Agriculture
16,7%
Personal experience
23,8%
Internet
40,5%

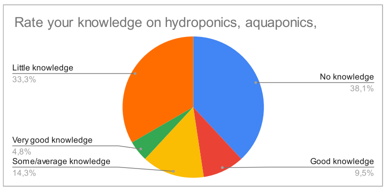

Which tools do you currently use to support your activities?
Traditional
4,8%
You own weather
7,1%
Smartphones?
4,8%
Weather data
16,7%
Field observations?
11,9%
Computers?
54,8%


What are the main issues/challenges you see in the agricultural sector?
Access to market
7,1%
Sale prices
4,8%
Availability and
7,1%
Cost of production
19,0%
Know how on best
42,9%
Other
19,0%


Rate your knowledge on crop protection and fertilization
Very good knowledge
9,5%
No knowledge
16,7%
Good knowledge
11,9%
Some/average
23,8%
Little knowledge
38,1%


Rate your knowledge on your access to market
No knowledge
9,5%
Some/average
23,8%
Good knowledge
16,7%
Very good
7,1%
Little knowledge
42,9%


Rate your knowledge on Water-Energy-Food-Ecosystems Nexus
Little knowledge
14,3%
Good knowledge
28,6%
Some/average
23,8%
No knowledge
9,5%
Very good knowledge
23,8%


Rate your knowledge on hydroponics, aquaponics,
Little knowledge
33,3%
No knowledge
38,1%
Very good knowledge
4,8%
Some/average knowledge
14,3%
Good knowledge
9,5%

4. TRAINING WORKSHOP DELIVERY

4.1 Content and structure of the training

Based on the results of the SGAQ training workshop was broken down into two main parts focussing on technical aspects and more business/marketed oriented aspects of the soilless technologies being developed within the AWESOME project.

The first session of the Capacity Building Training was undertaken by ZG partners, Mariam Hassanen and Nouran El-Said, who introduced the participants to the general concept related to the idea of the hydroponic technology and the different types of soilless agriculture systems. Taking into account the main challenges that the SGAQ's respondents face in the agricultural sector: access to market, cost of production, and know-how on best practices there was the need to explore why the hydroponics are gaining momentum now and based on the challenges that the case study area faces to introduce information on market opportunities. That would also address the big percentage of participants declaring no, little or some knowledge on the access to market.

The second session was undertaken by Aachen RWTH University with the aim to improve participants' knowledge on the cost-benefit trade off among soilless systems and conventional farming and then cover the knowledge gap on crop protection and fertilization as it was declared in the SGAQ. Particularly, covered aspects of misuse and overuse that is observed in the case study area and then presented in more technical details the experimental design of the hydroponics experiments on the lab level. A short presentation on desalination technology was given.

4.2 Delivery of the training

The Training was delivered on the 25th October 2023, at 10.00 local time (09.00 CET). Due to the current geo-political difficulties mentioned in section 1.1 the event took place online with the use of Google Meetings. It was attended by 26 different participants, whose backgrounds included agricultural engineer professionals and students based in Egypt.

The training was opened with an introduction to the AWESOME project and the day's training (both delivered by Lydia Stergiopoulou due to Andrea Castelletti's absence as a result of illness). This was followed by the a first introduction to the hydroponics and its fundamentals by Mariam Hassanen in English. A first Q&A took place and then a 10 minutes break. A part on the market opportunities and the hydroponics challenges was presented by Nouran El-Said in Arabic and after a Q&A a second break of 5 minutes took place. The second session run by Demet Cekin introduced the participants to the global issues of agriculture and aspects of economic benefits and quality control. A final break of 7 minutes took place and then Demet Cekin proceeded to the soilless cultivation systems and disease and pest management.

A translator hired from ZG team was translating the English presentations in Arabic and vice-versa.

Annex I includes the training material of the two sessions as it was presented to the participants, while Figure 1 below includes the agenda of the event.

AGENDA – Capacity Building Training

***Day of the meeting**: 25 October, 2023*
***Time:** 10.00 local time*
***Invitation link:** https://meet.google.com/iaj-gzqw-xop*

10.00 – 10.10	Introduction to the AWESOME Project (A. Castelletti)
10.10 – 10.30	Introduction to the Capacity Building Training (L. Stergiopoulou)
10.30 – 11.15	Hydroponics and technical fundamentals (Zon Gardens team) Hydroponics as an important aspect of the future of agriculture
11.15 – 11.20	Break
11.25 – 12.00	Market opportunities and hydroponics challenges (Zon Gardens team)
12.00 – 12.15	Q&A
12.15 – 13.00	Coffee break
13.00 – 13.10	Global issues in the agriculture sector (D. Cekin)
13.10 – 13.25	Key concept: soilless cultivation systems (D. Cekin)
13.25 – 13.40	Important environmental parameters for soilless cultivation (D. Cekin)
13.40 – 13.50	Application in soilless cultivation (D. Cekin)
13.50 – 14.00	Break
14.10 – 14.40	Integrated disease and pest management in soilless farming (D. Cekin)
14.40 – 14.50	Wrap up

Figure 1 –Agenda of the Training Workshop.

5. PARTICIPANTS FEEDBACK

Here follow the results from the feedback survey that took place at the end of the Capacity Building Training sessions.

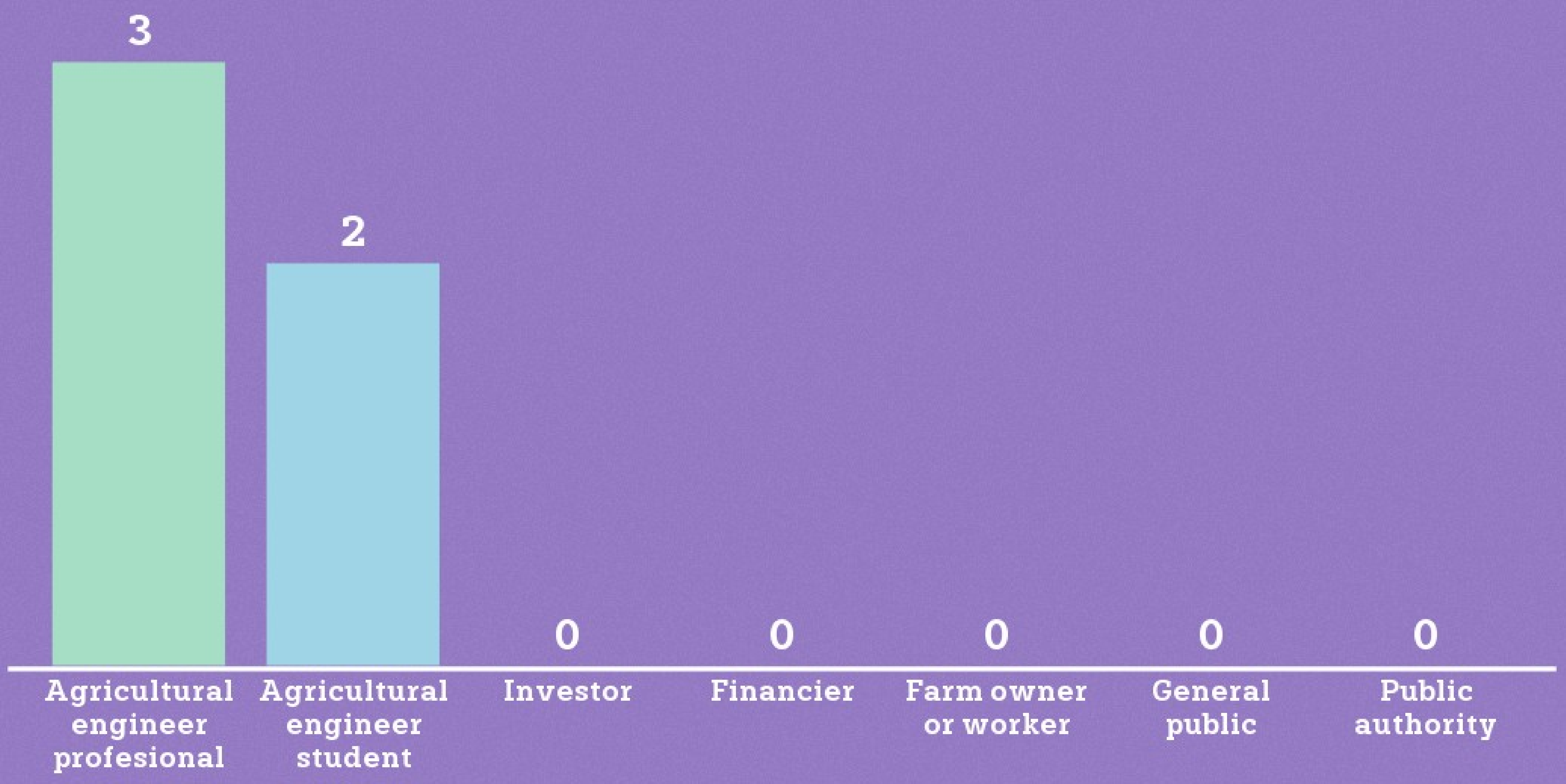
Welcome to this Training Feedback Survey template

Your opinion matters. Share your views with us!

4

Instructions

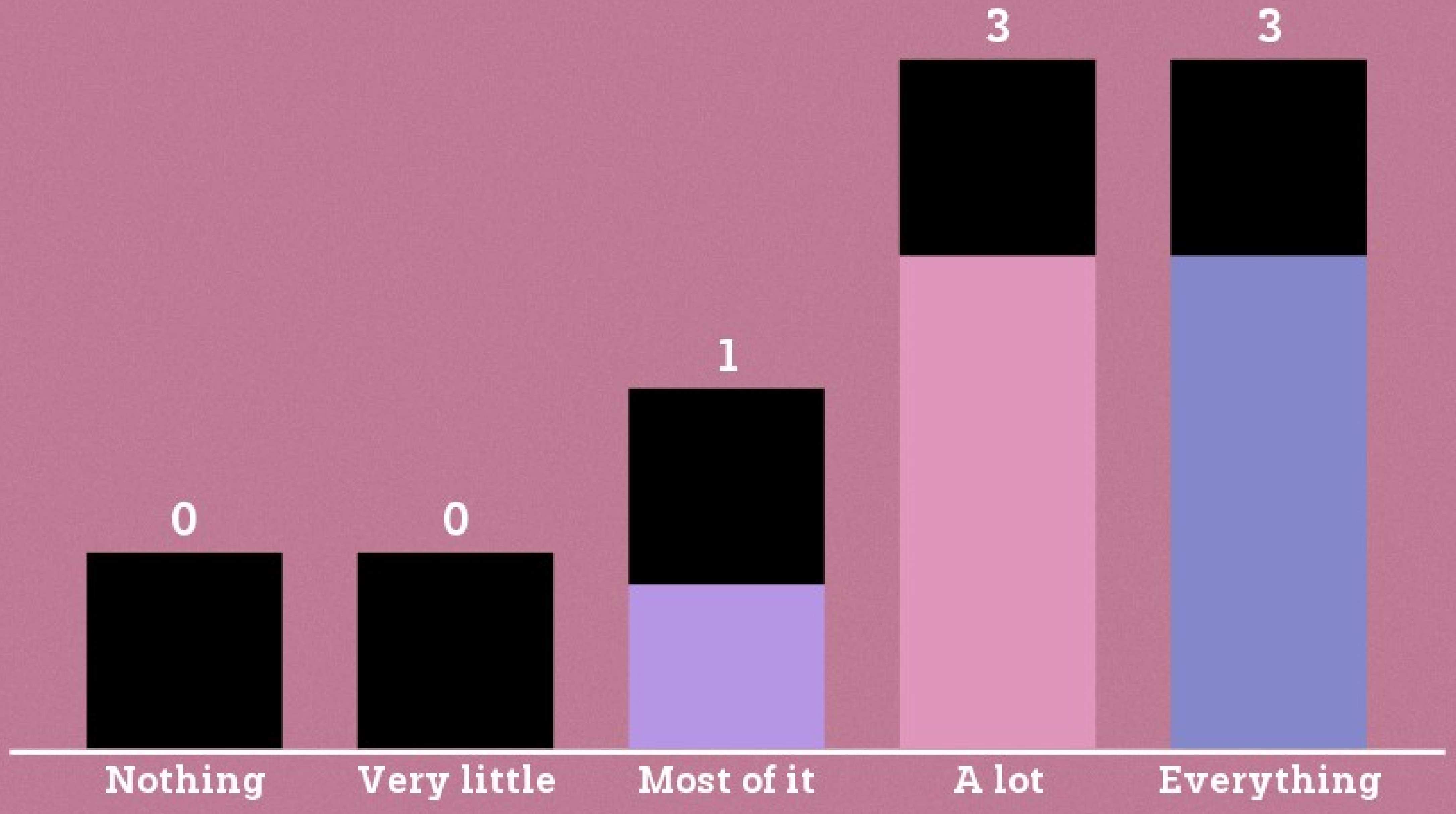
Which stakeholder group do you belong to?



Mentimeter

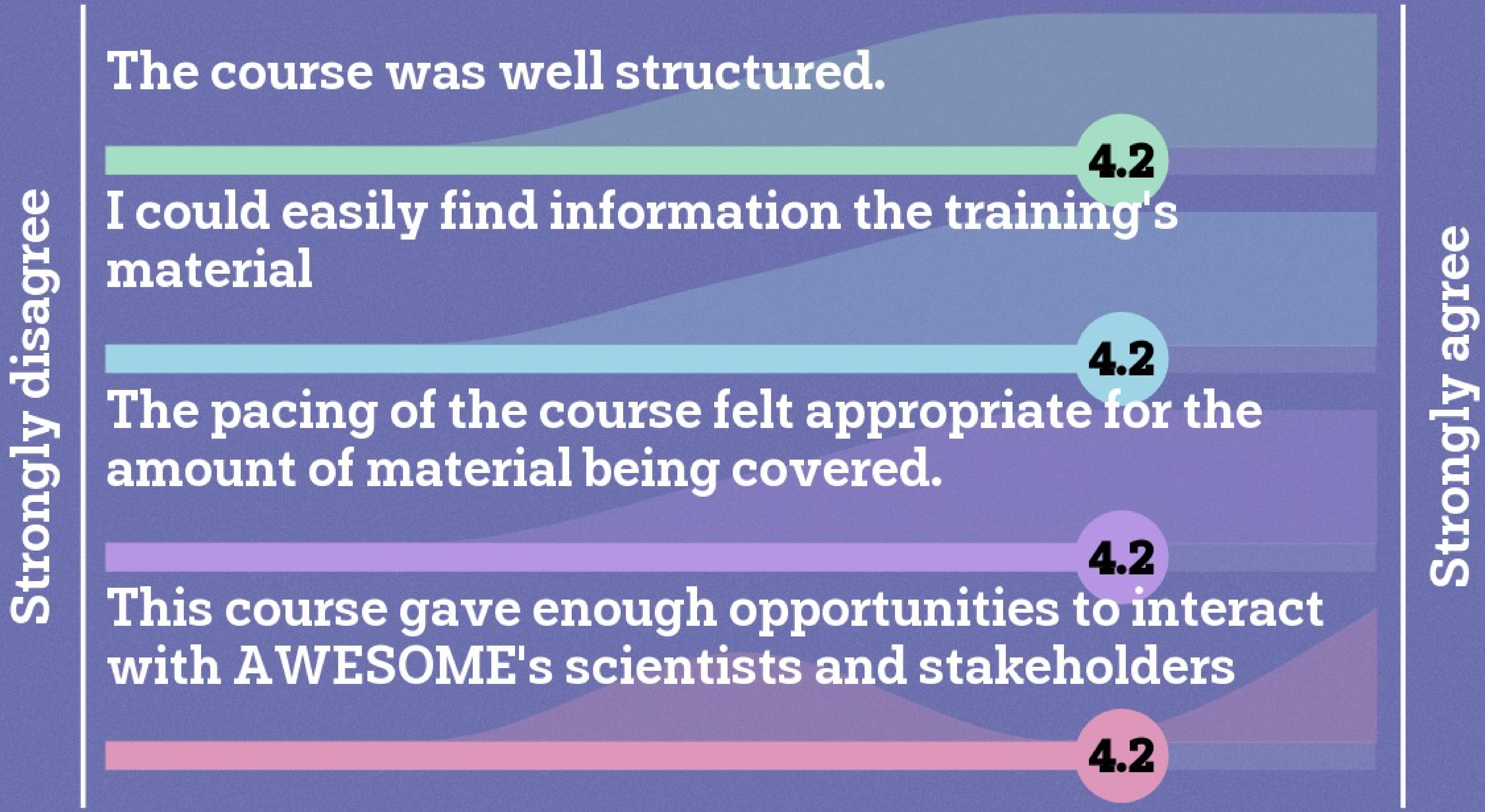
WEEKLY REFLECTION - CLASSROOM EXERCISE

On a scale of 1-5 how much did you understand of today's topic?



5

Evaluate the Course Structure



5

Mentimeter

What we could do better next time!

3 responses

It will be great if you makr a more specific courses in every part of soilless agriculture like IPDM in Hydroponics, nutrition and systems management

Maybe structure the presentation better to save time and not to repeat

Field visits and updates

1

3

One thing that was good about the course

4 responses

Trainers

Presenters are very friendly and collaborat

New info and connections

Naterial and ifoConnections

3

Thanks for the honest input

Let's be sure to take all of this onboard for our next projects!

4

6. KEY RECOMMENDATIONS FOR UPTAKING WEFE INNOVATION AT THE CASE STUDY LEVEL

Egypt Vision 2030, launched in 2016, represents the country's determination to create knowledge culture, and stimulate innovation especially when it comes to activities run by small and medium-sized enterprises and is reflected in the improved ranking of Egypt in the Global Innovation Index (GII) of 2022. Reliance on technology as well as R&D especially in the context of WEFE integrated approach will assist the country on the case study level and the national level to address pressing issues of water, energy, food and ecosystem challenges and have water utilization efficiency and productivity.

Based on findings from previous work contained on the main WEFE nexus challenges soilless technology (particularly with regards to innovation and technology, access and cost, as well as international cooperation and capacity development – D6.1[1], D6.2[2]), as well as feedback from stakeholders who participated in the skills gap assessment and the training workshop, the following recommendations regarding the uptake of WEFE Nexus Innovation can be made:

1. Decision-makers need to take into account the limited resources, awareness and updated know-how in order to assist growers and practitioners avoid relying on transferred practices there is a need to increase awareness on WEFE technology and innovation of practitioners in the field (e.g. development of educational curricula and expansion of application of techniques and tools) as well as the general public about the opportunities and the future of soilless agriculture.
2. There is a need for the improvement of legal frameworks for public-private partnerships to assist the private sector involvement in WEFE application and development following innovation hubs and soilless agriculture communities.
3. There is a need to address the issue of the high installation costs, e.g. with the development of support packages that incentivize new technologies for soilless agriculture, or capitalize on support from international organizations in the form of grants.
4. A focus is needed on the development and support of international collaborations with countries where soilless technology is more widely accepted and offer the opportunity for commercial exploitation in their markets
5. Linking the case study area with the wider regional setting for cooperation is important as well as linking the engineering solutions with other pertinent parameters – i.e. the consideration of some countries' dominance in certain markets, food and economic sovereignty, and national identity.
6. The use of solar powered pumps in combination with hydroponics and aquaponic systems can also mitigate the trade-offs related to increasing food needs (see D6.2 page 55).
7. The need for more sustainable strategies for reducing pesticide use against plant pathogens and pests in soilless systems as that can maximize the yields and reduce environmental impacts.

[1] Deliverable 6.1: Case Study Report
[2] Deliverable 6.2: WEF Mental Model

7. CONCLUSIONS

Global challenges such as population growth, demands for increased food production, and the pressures on resource (in addition to issues such as climate change, soil degradation, water scarcity, environmental pollution) are on the rise. There is an urgent need to find alternative, sustainable, and reliable ways to secure food supply. Innovative agriculture techniques such as hydroponics could provide part of the solution to these problems.

The report provides a description of the AWESOME researchers' attempt to capture the skills and identify the capacity building needs of the main beneficiaries from the soilless technique developed in the framework of the project. As well as the training material that was compiled in order to ensure that the tested technology will have the maximum uptake by the main practitioners that can be accessed by the team. The recommendations suggested as key directions for WEF Nexus innovations uptake at the case study level result from the scientists' and stakeholders' views as these were expressed during the Capacity Building Workshop.

There is a strong linkage between the work of Task 6.3 and the other WPs, mainly lying on the micro level experiments (WP5), the meso level designation of efficient portfolios (WP4) as well as the meso/macro level Science-Poligy Dialogue and Knowledge Transfer (WP7). The regional outreach workshops that were organized by WP7 (Summer School and Science- Policy event) were in conjunction with the Capacity Building Training and allowed the optimal dissemination of the projects' results, its exploitation opportunities and discussion of the wider implications for integrated WEFE Nexus approaches in the Mediterranean region.

ANNEX I

TRAINING MATERIAL – PRESENTATIONS

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PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

INTRODUCTION TO HYDROPONICS

SESSION 1

Mariam Hassanen

Research & Development Manager, Zon Gardens

Nouran El Said

Business Development Director, Zon Gardens

October 25, 2023 - Cairo

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Agenda

What is Hydroponics and what are its technical fundamentals

- What is hydroponic technology?
- Soilless agriculture VS Traditional agriculture
- Types of Soilless systems
- Complementary technologies for Hydroponics

Why is Hydroponics an important aspect of the future of agriculture

- Agriculture challenges in Egypt
- Overview of the SDGs and why they are important
- Why Hydroponics is gaining momentum?

Hydroponics Opportunities & challenges

- Market Opportunities
- Hydroponics challenges

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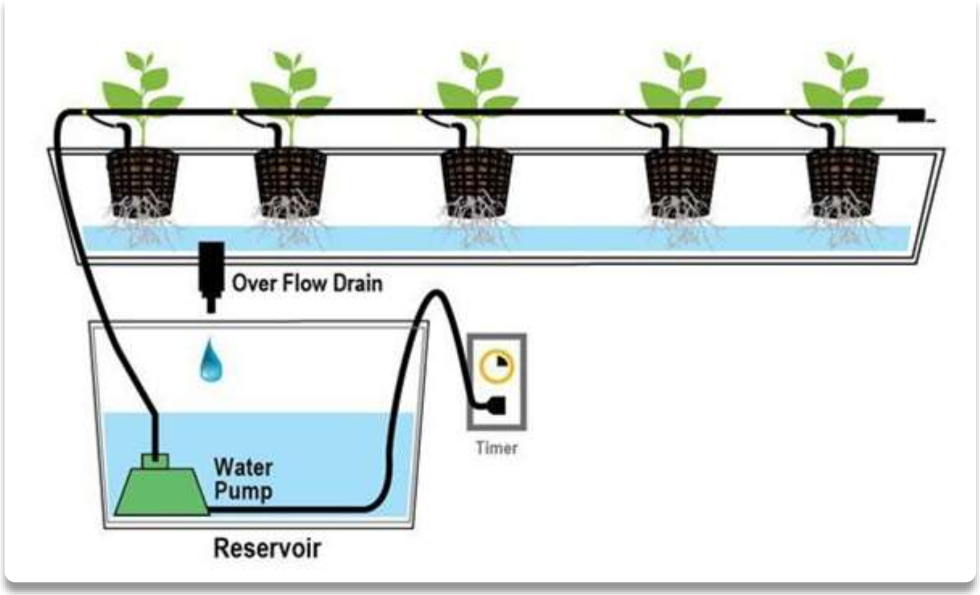
What is Hydroponics?

What is Hydroponic technology?



- Hydroponics is a high-tech method of growing plants in water rich in mineral nutrients instead of soil.
- Hydroponics is an ideal concept for today's agriculture sector which struggles to find new fertile lands for crop productions and will enable crops to be grown in greenhouses or in multilevel buildings.

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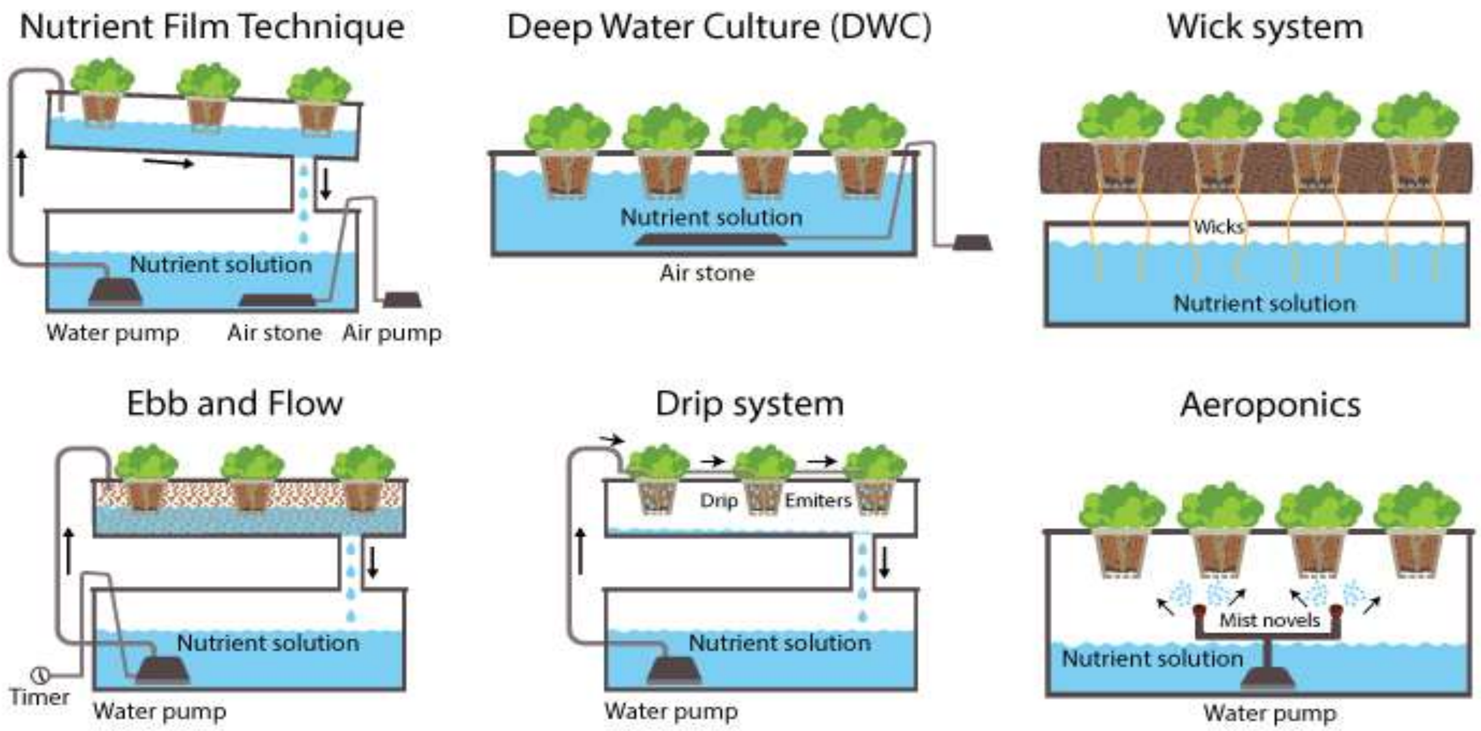
Hydroponics: A wonder of ancient world wonders

Why Hydroponics is gaining momentum?

Hydroponics Vs Traditional agriculture

POC	Soilless Agriculture	Traditional Agriculture
Area	Farming anywhere (desert, city, factory)	Soil suitable for cultivation must be used
Water Consumption	Saving 90% of water used for irrigation	90% water is wasted in the soil
Nutrition	Saving 60% in the use of fertilizers	Wasted use of fertilizers in the soil
Productivity	Increase productivity from same area up to 25x	Increasing productivity is linear with area
Control	High control on quality of water and easy sanitization measures	Soil borne pathogens can vigorously spread between crops
Agricultural Cycle	Cultivation of the crop in the same place throughout the year	Seasonal crop rotations and cycles
Cycle Duration	Shorter crop cycles by 30-60%	

Types of Soilless Systems- Hydroponics



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NFT System

Advantages:

- proper oxygen distribution among plants
- Easy to clean and sanitize
- Easy access to plants
- Plants can be transferred
- High control on nutrient solution

Disadvantages:

Low resilience to electricity and water cuts

DWC System

Advantages:

- proper oxygen distribution among plants
- Easy access to plants
- Maximized space utilization by decreasing service lanes
- High resilience (high temperature stability, continuous contact to water and nutrition)
- Plants can be transferred
- High control on nutrient solution

Disadvantages:

- High water and nutrition demand on initiation
- Medium susceptibility to pathogen spread among the same grow bed.

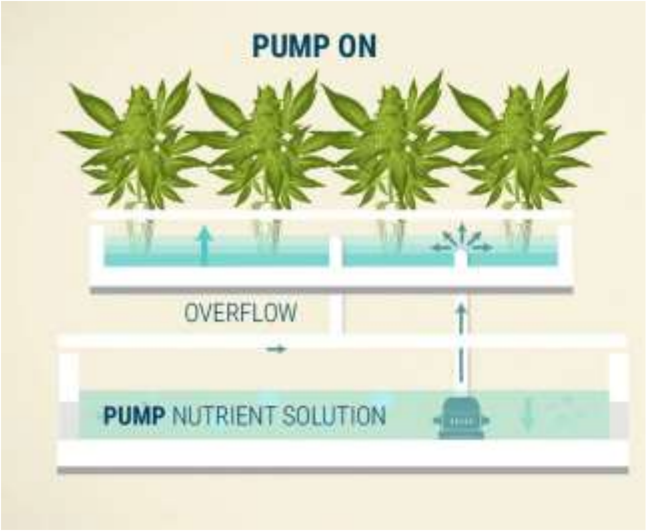
Ebb & Flow

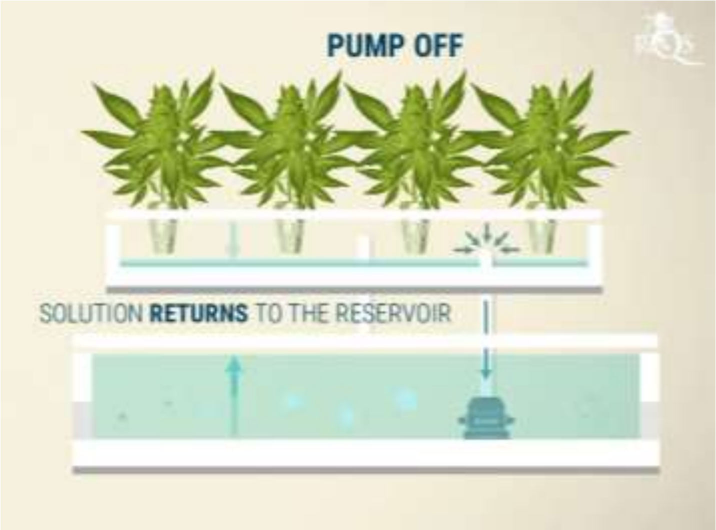
Advantages:

- Low initial cost
- Easy to install
- High control on nutrient solution

Disadvantages:

- Low resilience to electricity and water cuts





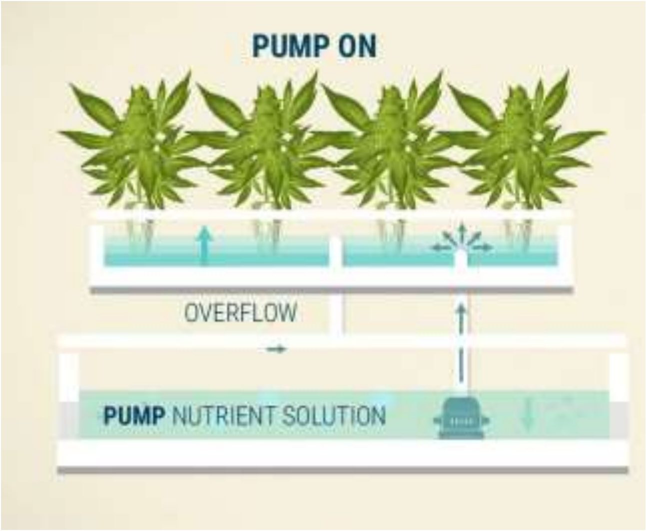
Drip irrigation

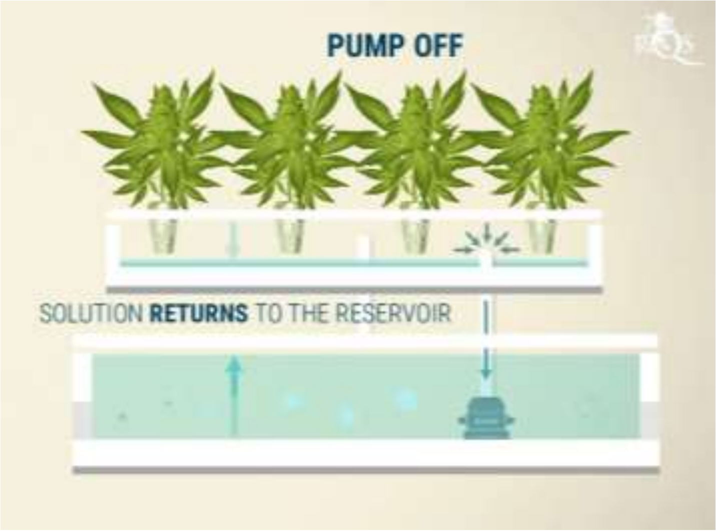
Advantages:

- Low initial cost
- Easy to install
- High moisture retention

Disadvantages:

- Nutrient accumulation disrupting balance.
- High dependance on electricity





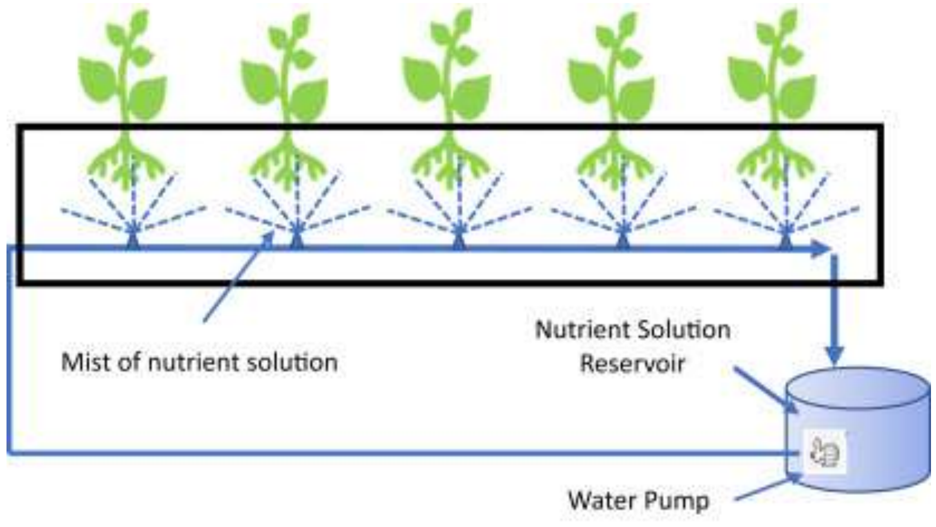
Aeroponics

Advantages:

- Highest oxygen Supply among plants
- Easy to clean and sanitize
- High control on nutrient solution
- lowest pathogen transfer in the same grow bed

Disadvantages:

- Continuous monitoring is required
- High technical knowledge is required
- High dependability on automation



Types of Soilless Systems- Hydroponics

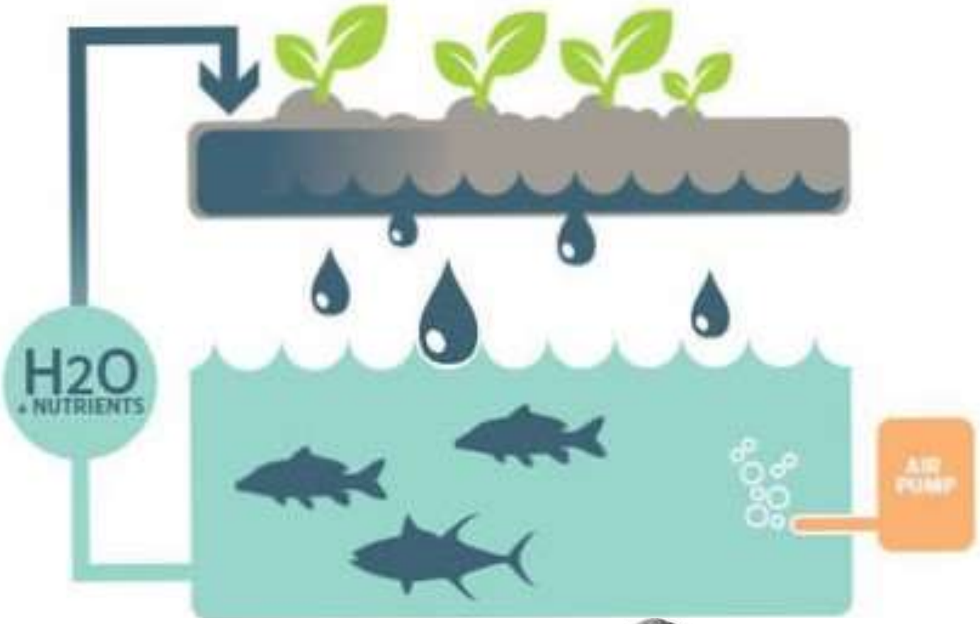
	Deep Water Culture (DWC / HRS)	Nutrient Film Technique (NFT)	Substrate-Based: Mediabed (Ebb and Flow)	Substrate-Based: Dutch Bucket (Drip)
Optimal for Lettuce	✓	✓		
Optimal for Herbs	✓		✓	
Optimal for Kale & Cabbages	✓		✓	✓
Optimal for Tomato/Pepper			✓	✓
Optimal for Strawberry		✓		✓
Spacing Mode	Dynamic in 2-axis	Dynamic in 1-axis	Static	Semi-Static
Relative Cost	+++	++++	++	+
Water Temperature Sensitivity	Large Temp. Buffer	Sensitive to Temp.	Less Sensitive to Temp	Less Sensitive to Temp.
pH & EC Adjustment Frequency	15 days	Daily	Weekly	2 – 3 days
Nutrient Control and Monitoring	Manual or Automatic	Automatic	Manual or Automatic	Manual or Automatic
Area Utilization Effeciency (Grow Area/Greenhouse Area)	87.5%	65.5%	<65%	<65%

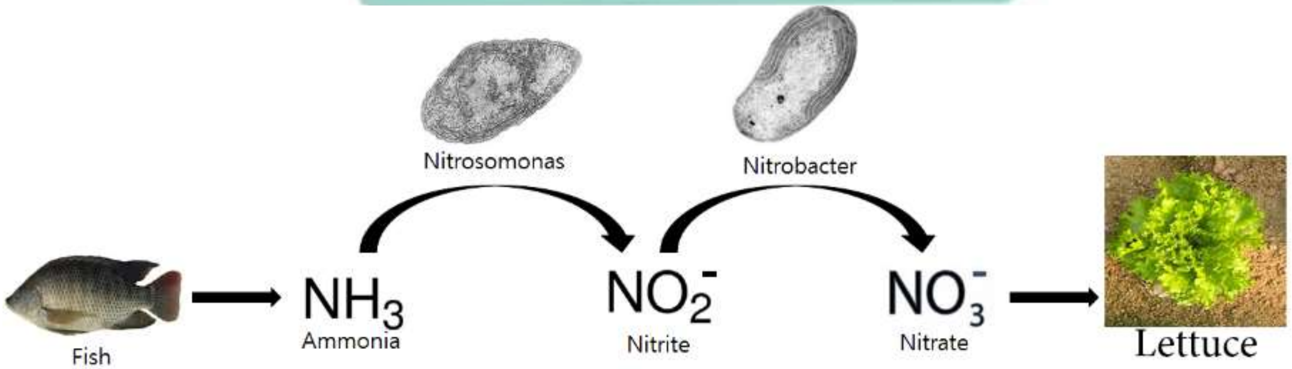
Types of Soilless Systems- Aquaponics

This system is a mixture of 3 living organisms (plants - fish - bacteria) where ammonia produced from fish is used after converting it to a soft form (nitrate) by bacteria (biological filter) to fertilize and feed plants and block solid fish waste through the mechanical filter

Thus, two types of nutrition are produced for humans:

- Animal protein (fish)
- plants





Complementary systems

Cooling fans

•**Greenhouse structure**

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Complementary systems

Artificial lighting

•Cooling Pads

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Why is Hydroponics an important aspect of the future of agriculture?

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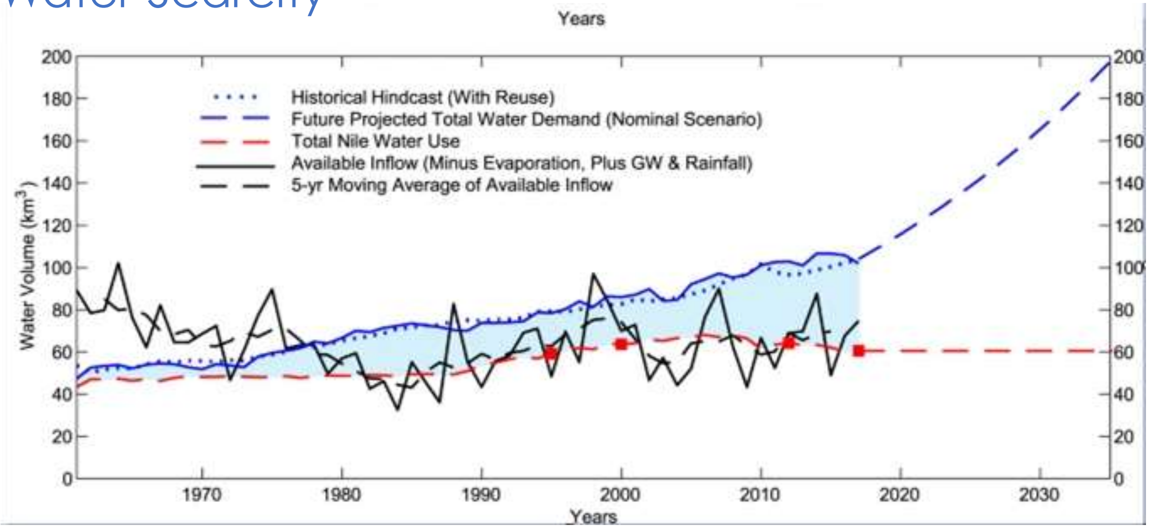
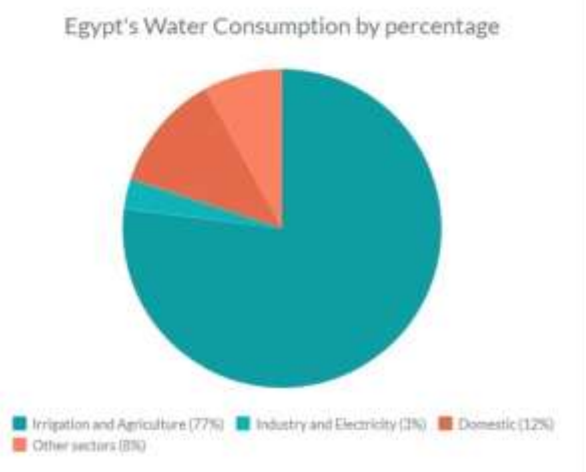
Agriculture Challenges in Egypt

Water Scarcity





Egypt is facing an annual water deficit of around seven billion cubic metres and the country could run out of water by 2025, when it is estimated that 1.8 billion people worldwide will live in absolute water scarcity (source: IPS)

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Agriculture Challenges in Egypt

Wrong Practices

Due to the limited resources, awareness, and up to date technical know-how, growers often rely on transferred practices that can be scientifically unfounded or sometimes even harmful.

Examples:

- Relying on nutritional supplements instead of studying plant needs and providing proper nutrition
- Overuse of pesticides
- Wrong nutrition and combating applications

Agriculture Challenges in Egypt

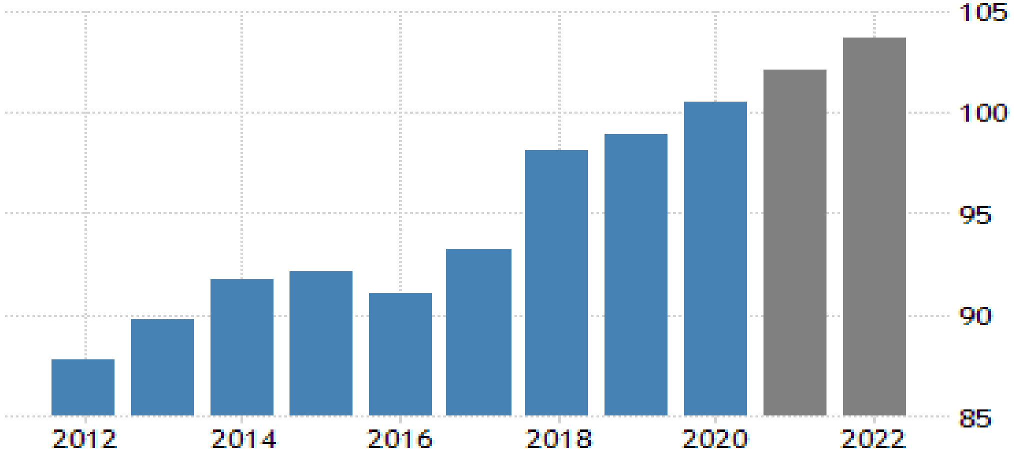
Desertification

The United Nations describes desertification as “the degradation of land in arid, semi-arid and dry sub-humid areas” due to human activities and climatic variations. One of the aspects that have had a major effect on agriculture in Egypt is the desertification of land in Egypt; this problem is manifesting itself in a huge food gap [which] will widen even more in the future as we lose more agricultural land to desertification. Increasing desertification has also affected water availability. Egypt’s 55.5 billion cubic meter share of Nile water is already insufficient to satisfy the country’s growing needs.

Agriculture Challenges in Egypt

Increasing Population

Egypt has a population of about 102 million people. According to current projections, Egypt’s population is expected to double by 2078. The population is currently growing at a rate of 1.94%, a rate that adds about 2 million people to the population every year.



Agriculture Challenges in Egypt

Climate change

The potential impacts of climate change in Egypt — brought on by considerable loss of agricultural land and rising temperatures — are hard to ignore. They include reduced crop yields, food insecurity, and water stress, with rising sea levels also threatening coastal populations in the country.

Agricultural production in the country may decrease by eight to 47 percent by 2060, which would be coupled with employment losses of up to 39 percent, according to a 2013 report released by the United Nations Development Programme (UNDP), which was produced in collaboration with the Egyptian government and a number of other UN agencies.

Agriculture Challenges in Egypt

Climate Change

How is climate change affecting Egypt ?

- Temperatures in Egypt have increased at a rate of 0.1°C per decade on average between 1901-2013.
- Over the past 30 years, the increase has intensified with average temperatures increasing by 0.53°C per decade.
- Over the past 30 years, total precipitation has dropped by approximately 22%
- The past 2 years growers have witnessed huge drops - as high as 90%- in the output of many crops.

Overview of the SDGs and how Hydroponics contributes to it

Hydroponics might be the way to unlock sustainable intensification without provoking reckless deforestation and water pollution, enabling businesses to pursue sustainable strategies while also investing in innovation and increasing their earnings.

9 out of 17 United Nation's Sustainable Development Goals for 2030 are relevant to the AgriFood production sector:

1. SDG 2 – Zero Hunger
2. SDG 3 – Good Health & Wellbeing
3. SDG 6 – Clean Water & Sanitation
4. SDG 7 – Affordable & Clean Energy
5. SDG 8 – Decent Work & Economic Growth
6. SDG 10 – Industry, Innovation & Infrastructure
7. SDG 11 – Sustainable Cities & Communities
8. SDG 12 – Responsible Consumption & Production
9. SDG 13 – Climate Action

Why Hydroponics is gaining momentum?

- Lower risk than traditional agriculture
- Consistent production quality 365 days a year
- Shorter crop cycles and faster cash cycles
- Higher return on investment
- International organizations support in the form of capacity building, grants, research, and more
- Commercial application is feasible and success stories are increasing
- Technology is widely accepted abroad
- Governmental support and funding in the GCC (e.g.: exceeding USD 300 Mn in UAE) – expected in Egypt soon

Hydroponics Opportunities & challenges

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Hydroponics Opportunities

- Established commercially profitable crops - pay-back period 14-24 months:
  - Leafy greens
  - Fruiting crops: Cherry tomatoes
  - Fruits: Strawberry
- Market access through emerging businesses
  - Online market platforms (B2B: El Supplier & B2C: Breadfast & Rabbit)
  - Traders (e.g.: fresh source, agroavate)

Hydroponics Challenges

- The high cost of establishing a farm with a soilless cultivation system
- The high amount of electricity consumption (the alternative is to use renewable energy - capital intensive)
- Limited number of experienced calibers
- It is difficult to obtain sufficient data for most of the crops except for a certain group of crops (such as leaves, vegetables, and herbs) because the technology is relatively new

Hydroponics Opportunities

- Technology access
  - Variety of technology components are available locally; for example:
    - Alex Hydroponics
    - Tomatiki
    - ReNile
    - Plug’n’Grow
  - Sourcing technology from abroad is feasible – but not economic –
  - Complementary technology and services are available (e.g.: IOT, automation, management software, etc.)

- Export subsidies

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Hydroponics Opportunities

International organisations support

- Capacity building
- Research grants

Funding opportunities

- Egyptian Agriculture Bank
- Alex Bank
- National Bank of Egypt
- Mozar3
- Grants

HYDROPONICS PROJECTS' FINANCING

Access to Financing opportunities for hydroponic systems in Egypt is a crucial aspect of establishing and expanding hydroponic operations.

Even though, the initial setup costs of hydroponics systems and ongoing expenses can be significant, **Banks, governmental institutions, non-governmental organizations, financial developing institutions, private sector financing institutions** are all availing their services to financially support the small holder farmer with cost associated with **assets & working capital.**

BANKS

Banks or ‘traditional lending programs’ offer debt financing, credit facilities and loans.

Eligibility criteria:

- Established businesses will have to provide financial statments on which the credit limit will be set.
- Newly established and startups are required to provide a feasibility study.
- Some banks require from 2 to 3 years of business.
- Requires guarantees.

Exmaples of these banks are: CIB, AAIB, NBE, NBK, QNB and EGBANK.

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PRIVATE SECTOR FINANCING INSTITUTIONS

Direct Leasing, Sale and Lease Back Factoring & are some of the form of this kind of financing.

Eligibility criteria:

- No years in business required, but must be profit generating.
- Must have a source of income
- The lessor have a property.
- Different types of guarantees are taking by the lender.

Examples of these institutions: Valu, Contact financial Holding, Ghabbour Leasing, Dayra, Flapkap.

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GOVERNMENTAL & FINANCIAL DEVELOPING INSTITUTIONS

Government tailored subsidies, grants, discounted interest rates are all initiatives geared towards the development of the agriculture sector, this implies that their eligibility criteria are the easiest to fulfil.

Eligibility criteria:

- No years in business required.
- Newly established and startups are required to provide a feasibility study.

Examples of these institutions: 5% interest rate intative offered by many banks like CIB, QNB, NBE, ADIB and Banque Misr, the Egyptian SME’s develompemnt agancy, EBRD & GEFF, Agriculture Bank Of Egypt

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WP5 – MICRO LEVEL MODELS

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2023-10-25, Online

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WP5 – MICRO LEVEL MODELS

Content

- Global issues in the Agriculture Sector- 10 min
- Key concept: Soilless cultivation systems-15 min
- Important environmental parameters for soilless cultivation-15 min
- Applications in soilless cultivation-10 min
- Integrated Disease and Pest Management in soilless farming-30 m

ECOLOGICAL ASPECT

Benefit-cost trade-offs in soilless systems

Comparation of agricultural systems

Resource use in several agricultural systems and comparison between soilless farming and convectional farming

Reduction of the negative environmental impacts agricultural activities

use of pesticides, mineral fertilisers in different systems

LAND USE

Conventional Farming

- Crop production volume per land area steadily decreased
- Due to concretion and natural disaster
- Global warming causes an increase in the rate of dry land (FAO, 2016)

In Soilless systems

- Increase the quantity of crops obtained per unit of land surface and reduce the pressure on agricultural land
- Allow the usage abandoned buildings (i.e old factories), rooftops, and unused and unsuitable soils
- Provide possibility of cultivation for urban and peri-urban areas
- Vertical farming systems to maximize productivity and reduce costs related to different technical factors

Vertical farming

How large do you estimate the share of freshwater withdrawal that is used for irrigation purposes?

WATER USE

Global water use by sector

WATER USE IN CONVENTIONAL AGRICULTURE

Excessive use of water for irrigation- sinkholes

WATER USE

Conventional Farming

- Wrong irrigation methods
- Requires the higher volume of water
- Water losses by infiltration over the root zone in soil

In Soilless systems

- Consume 10-30 times less
- Recirculated water and reuse of water
- Efficient water use
- The evaporation is at low level

Go green aquaponics

CROP ROTATION

Conventional Farming

Crop rotation is the practice of planting different crops sequentially on the same plot of land to improve soil health, optimize nutrients in the soil, and combat pest and weed pressure. For example, say a farmer has planted a field of corn. When the corn harvest is finished, he might plant beans, since corn consumes a lot of nitrogen and beans return nitrogen to the soil.

In soilless systems

year-round cultivation in controlled greenhouses

FERTILIZER USE

Conventional Farming

- Salted or calcified in soil by changing pH value
- Nutrient uptake not sufficient for plant growth
- Contamination in soil and ground water (mis- and over-use)
- Needs other process to make the soil healthy

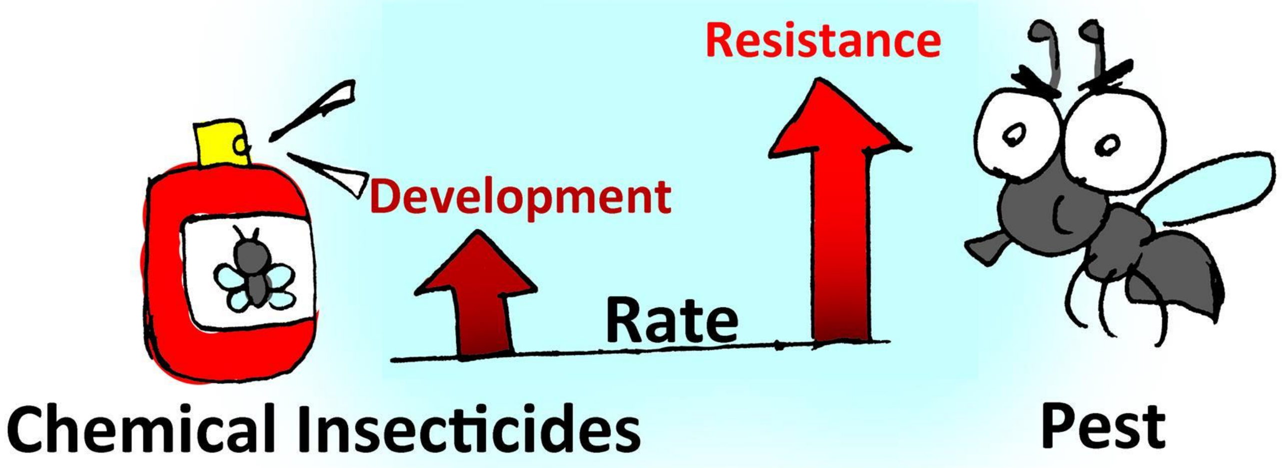
ws.net

In soilless systems

- The recirculation of the nutrient solution
- Special hydroponic formulation with nutrients for optimal plant growth
- In aquaponic system, plant uptakes nutrients from fish waste

Resistance Development

Some common pests develop resistance to my pesticides

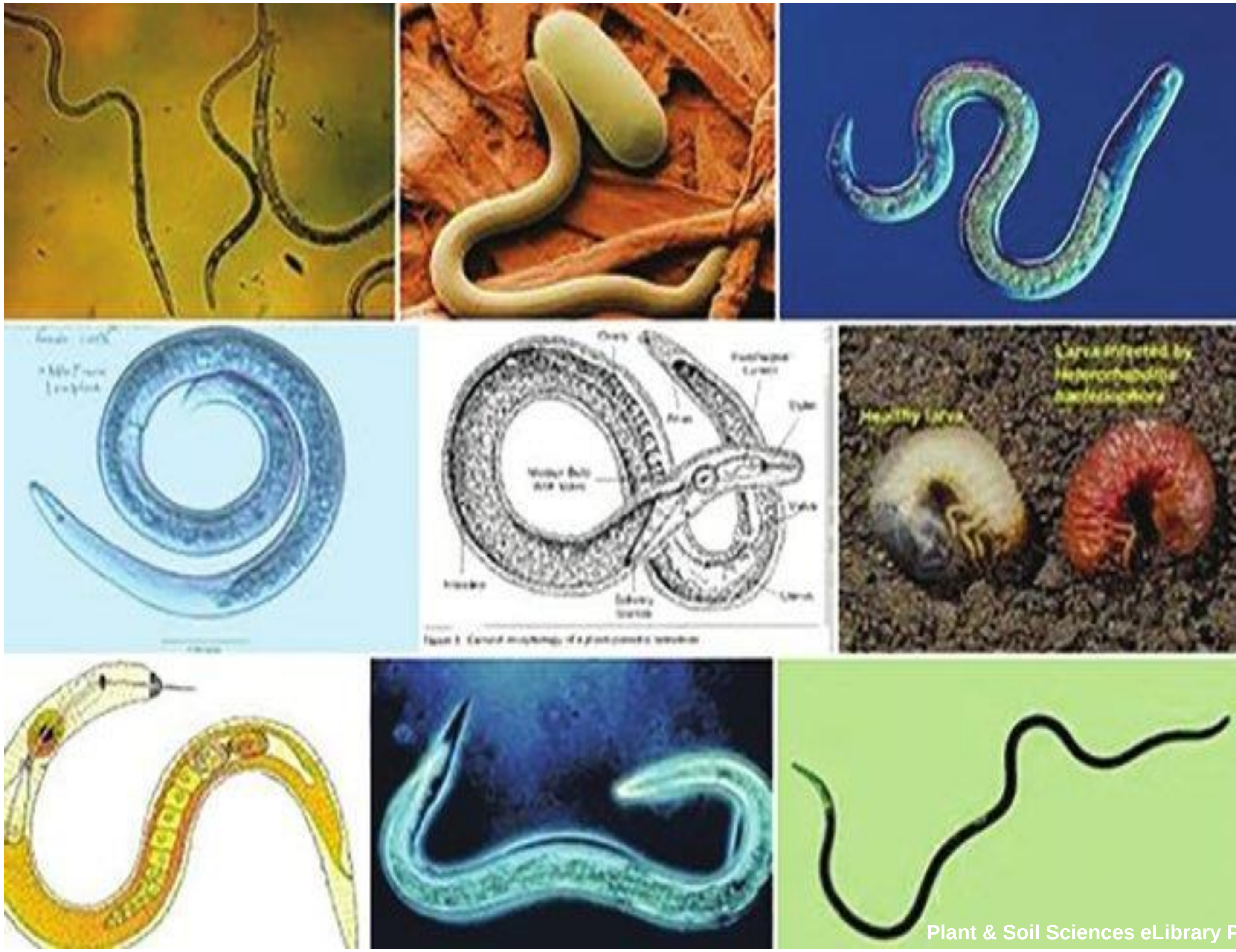


ugaurbanag

THE MISUSE (INCLUDING OVERUSE) OF PESTICIDES

Negative environmental impacts in soil

Ground water, air and soil
Small- sized nematodes contrubitions for vitality
to terrestrial ecosystem and provide dranige in soil



Beneficial nematodes in the soil

IDEA League
Connect. Exchange. Innovate.

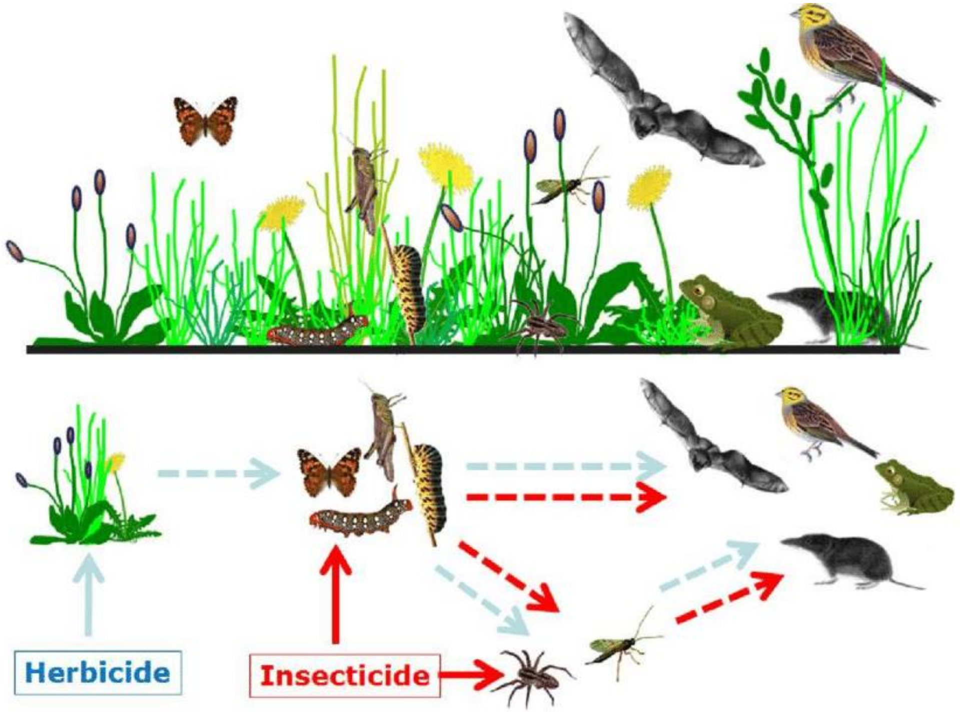
THE MISUSE (INCLUDING OVERUSE) OF PESTICIDES

Negative environmental impacts in Ecosystem

Detrimental effect on marine ecosystem, fresh water ecosystem, mammals, birds,reptiles etc.

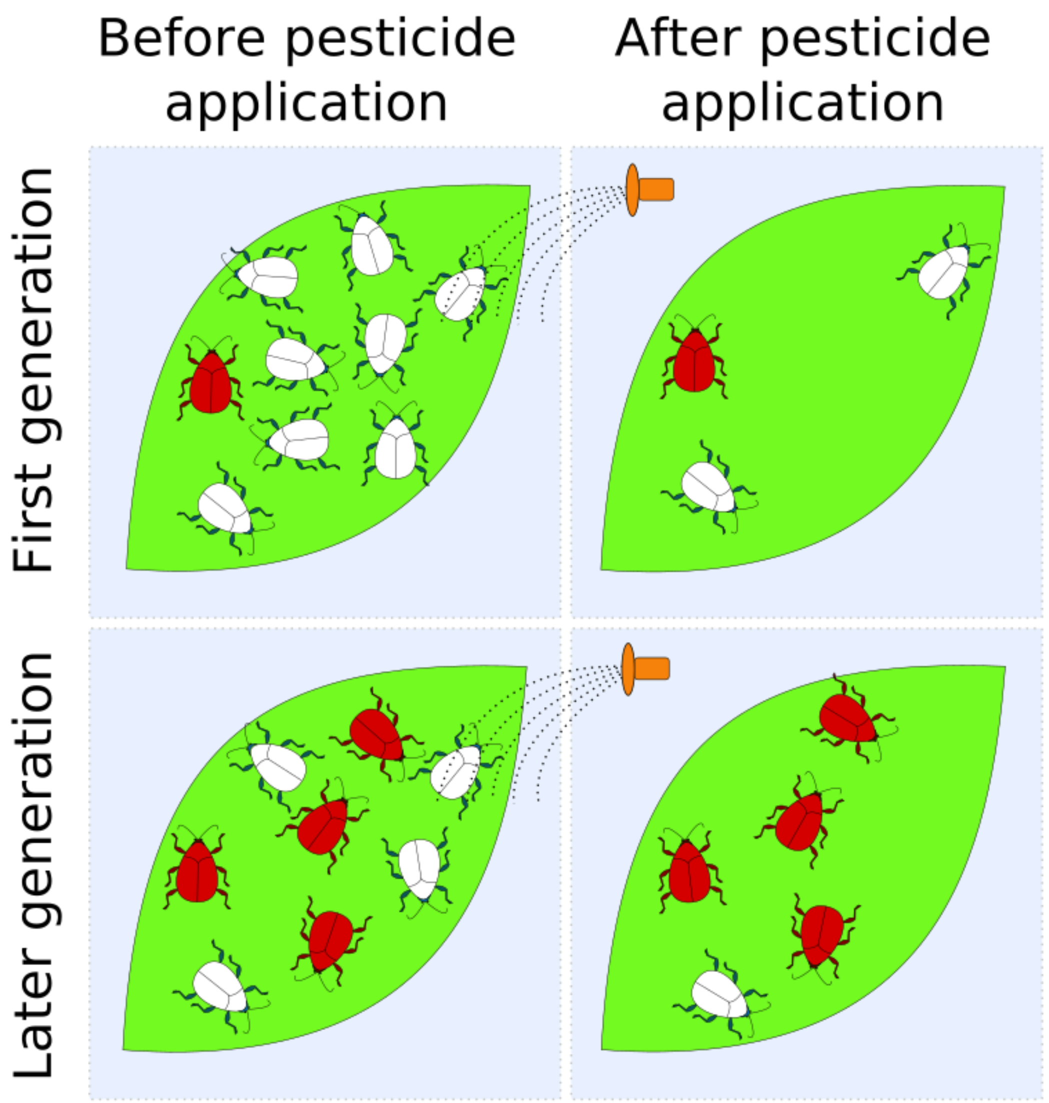
Negative environmental impacts in agricultural area

Toxic and/ or lethal on non-target organisms such as predators, competitors, herbivors, symbionts, parasites, and pathogens



Above: Presence of non-target organisms. Below: Direct (solid arrows) and indirect effects (dashed arrows) of pesticides, blue: herbicide, red: insecticide. (Brühl, 2017)

SECONDARY PEST OUTBREAK



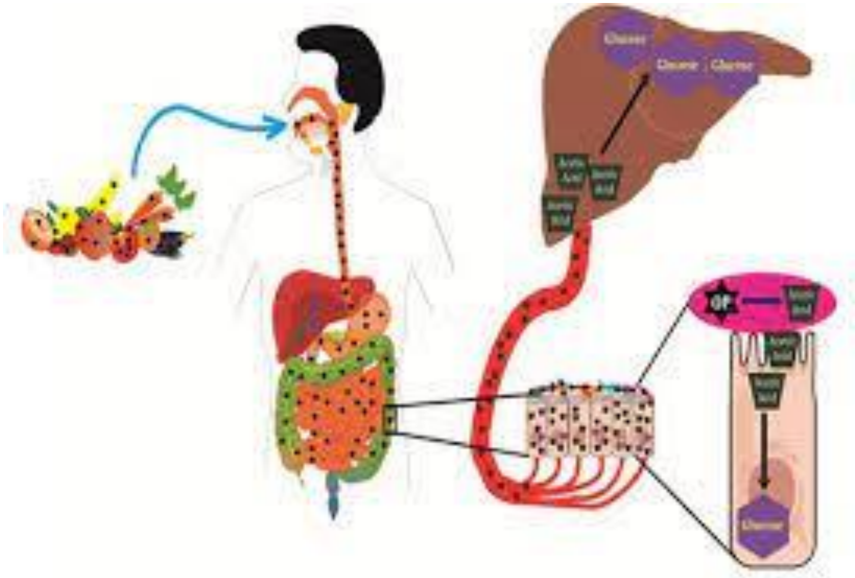
THE MISUSE (INCLUDING OVERUSE) OF PESTICIDES

Human health

Some pesticides may negatively affect human health

Negative effects on organs

Organophosphorus pesticides commonly accumulated in adipose tissues in liver and kidney and can consequently lead to serious health problems



GLOBAL PROBLEMS

Water scarcity

2/3 of the global population (4.0 billion) people suffer under severe water scarcity (min. 1 month/ year)

Growing World Population

2019	7.7 billion people
2050	9.7 billion people

Climate Change

Increase of extreme weather events like droughts and floods

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TRADITIONAL FOOD PRODUCTION

Traditional crop cultivation

Crop cultivation in fields managed with large agricultural equipment, usually in monocultures.

Traditional Aquaculture

Farming of aquatic organisms (fish, molluscs, etc.) in semi-/ intensive cultures on- and offshore.

Fishing of wild stocks

Commercial fishing with net fishing, trap fishing and other techniques.

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WEAKNESSES OF TRADITIONAL TECHNIQUES

TRADITIONAL FARMING

- Increasing soil degradation
- Fertiliser leaching
- High pesticide consumption

TRADITIONAL AQUACULTURE

- High drug consumption to prevent diseases
- Negative impact on surrounding ecosystems

FISHING OF WILD STOCKS

- Overfishing

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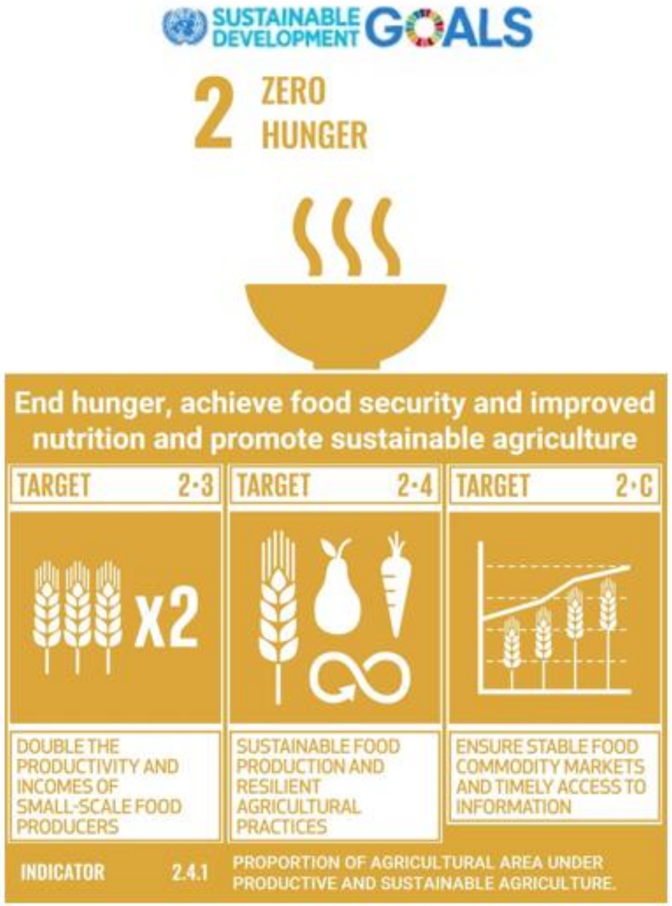
'Human rights begin with breakfast'

this quip from the former President of Senegal, Leopold Senghor



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BENEFITS

Soilless systems

- Less pesticides are used
- need shorter time for cultivation
- Parameters are adjustable for optimal plant growth

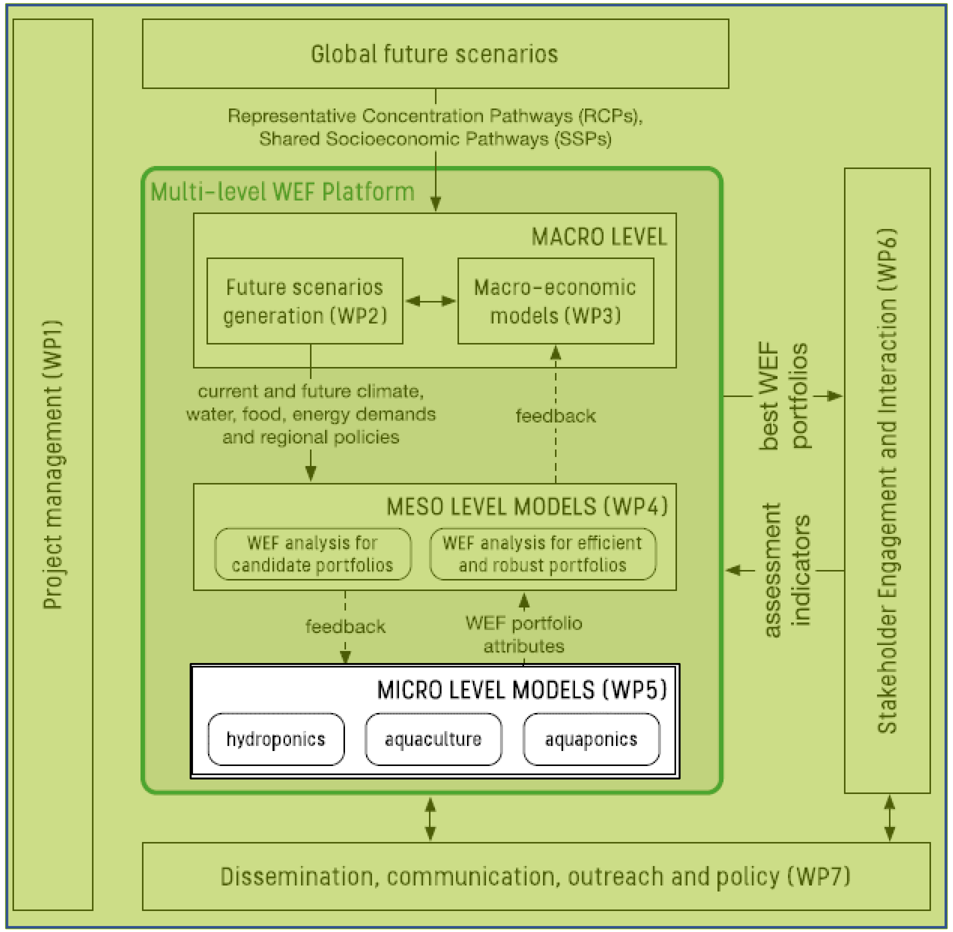
WP5 – MICRO LEVEL MODELS

Objectives

Demonstration of the **potential of new technological solutions** to **maximize water productivity** in terms of valuable products like **crops and fish**.

AWESOME KPI.4: increase in crop productivity per unit of water compared to standard agriculture.

Target: 8 times



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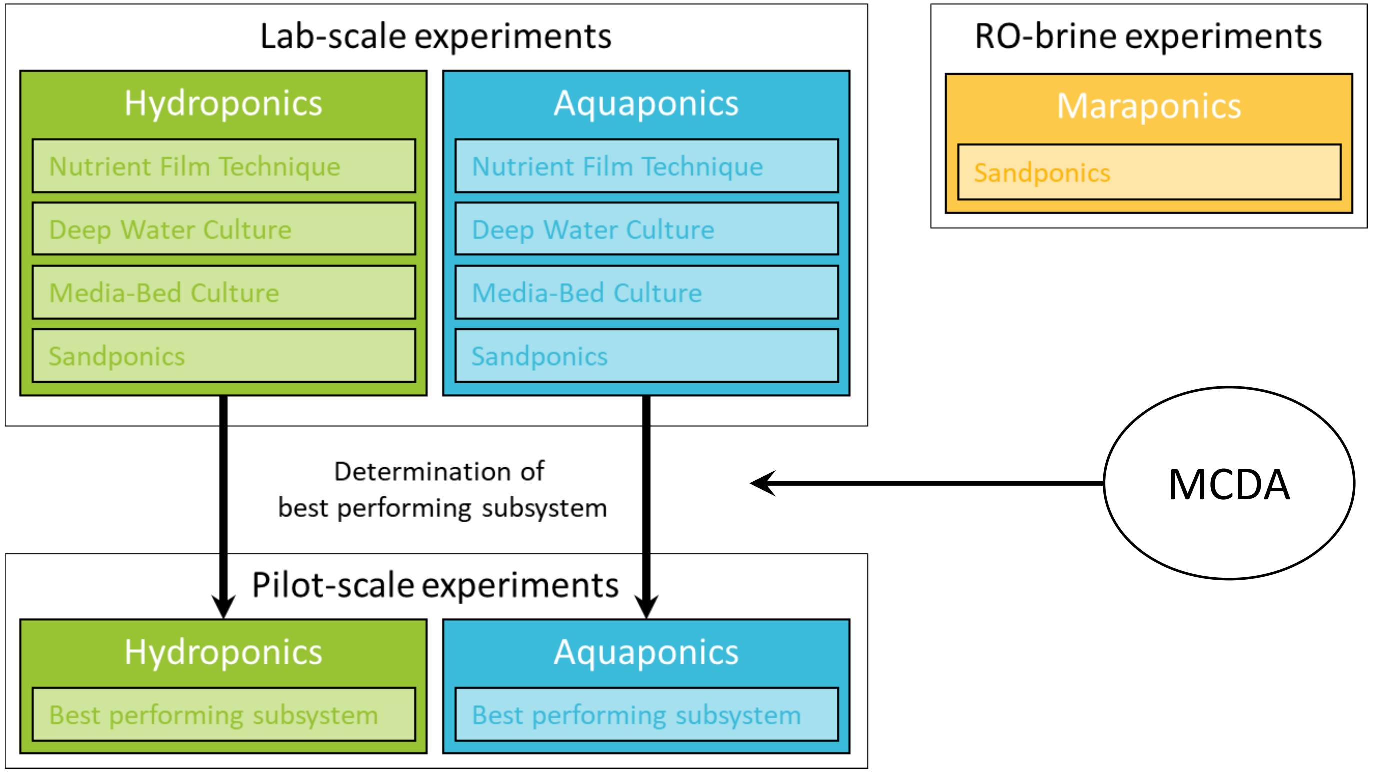
WP5 – MICRO LEVEL MODELS

Overview of the experiments



AWESOME
WATER-ECOSYSTEM-FOOD

INNOVATIVE AGRICULTURE TECHNIQUES

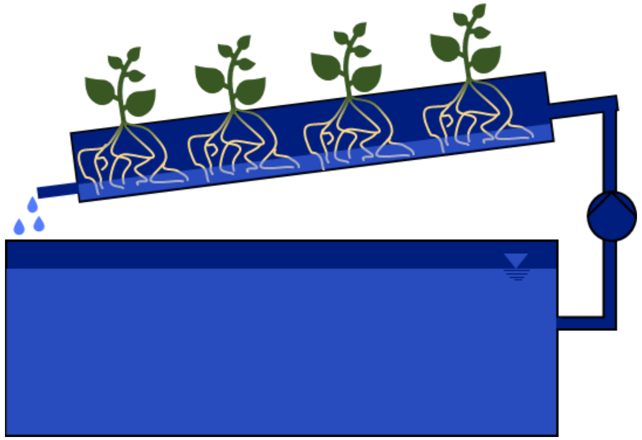
Hydroponics

- Soilless plant cultivation technique with the roots submersed in a nutrient solution.
- Plants are grown in an artificial, closed system predominantly independent of the natural environmental conditions.

HYDROPONICS

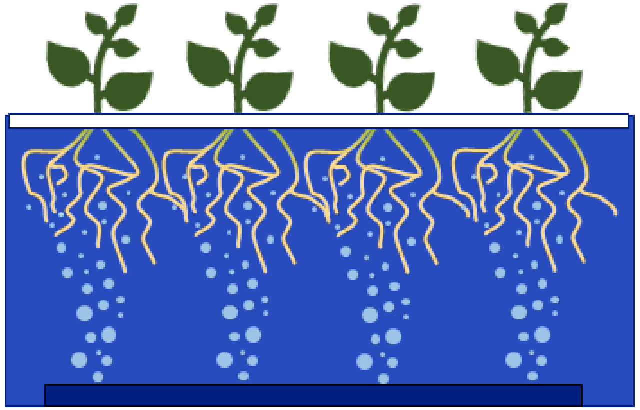
Nutrient Film Technique

A shallow stream of nutrient solution is directed through a pipe system to moisten the roots and provide for nutrients.



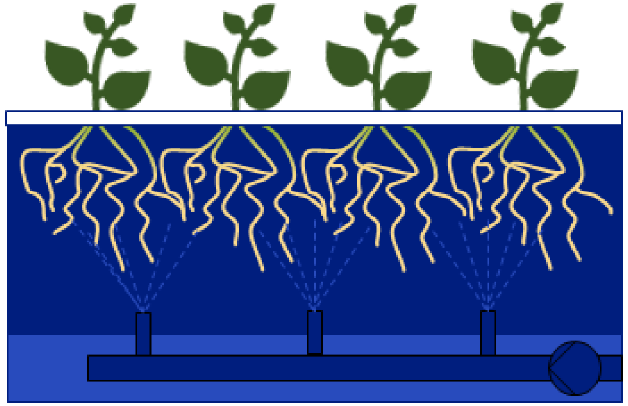
Deep Water Culture

The plants are on a floating raft with the roots submersed in a nutrient solution. Air pumps provide for sufficient aeration.



Aeroponics

The roots of the plants are sprayed with nutrient solution.



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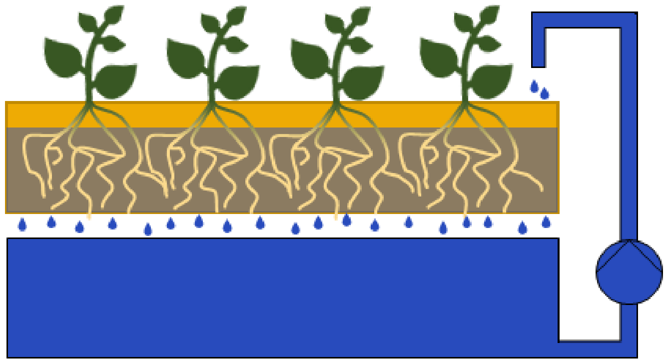
HYDROPONICS

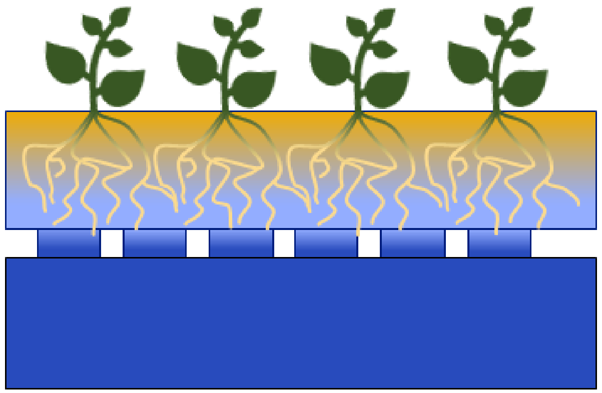
Media-bed Culture

The plants are planted in inert substrate. Via drip irrigation or flood-and-drain the nutrient solution is provided.



Sandponics

Special type of a Media-bed culture using sand. New systems rely on capillary forces and the ability of plants to draw water.



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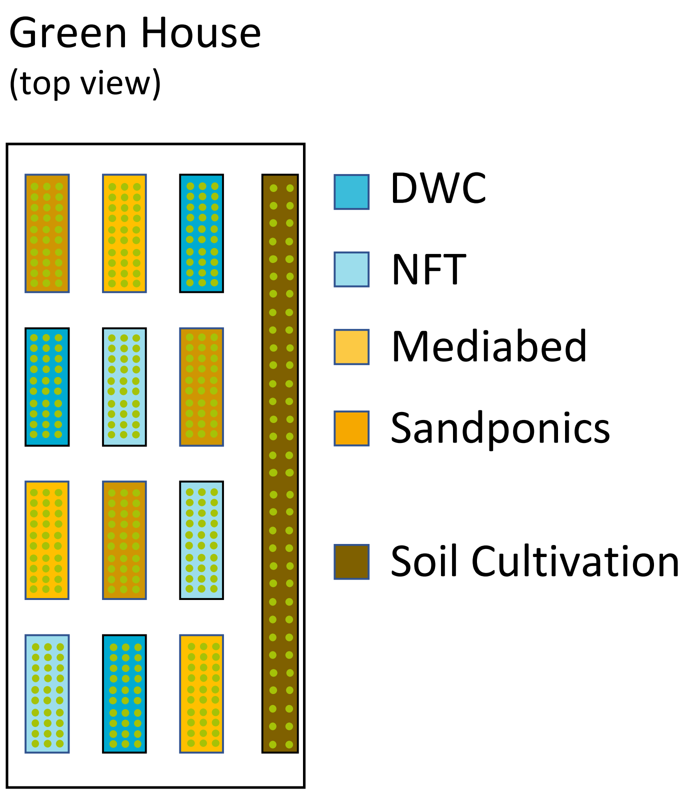
HYDROPONIC LAB-SCALE EXPERIMENTS

Experimental Design

- Test species: lettuce (*Lactuca sativa*)
- Testing cultivation methods, planting spacing and planting seasons
- Experiments with 4 hydroponic systems (DWC, NFT, Media-bed, Sandponic) and soil cultivation
- Plant spacing treatments (narrow and large)
  - Hydroponic systems: 20 x 25 cm, 24 x 25 cm
  - Soil Cultivation: 30 x 45 cm, 35 X45 cm
- 2 trials in summer and winter seasons



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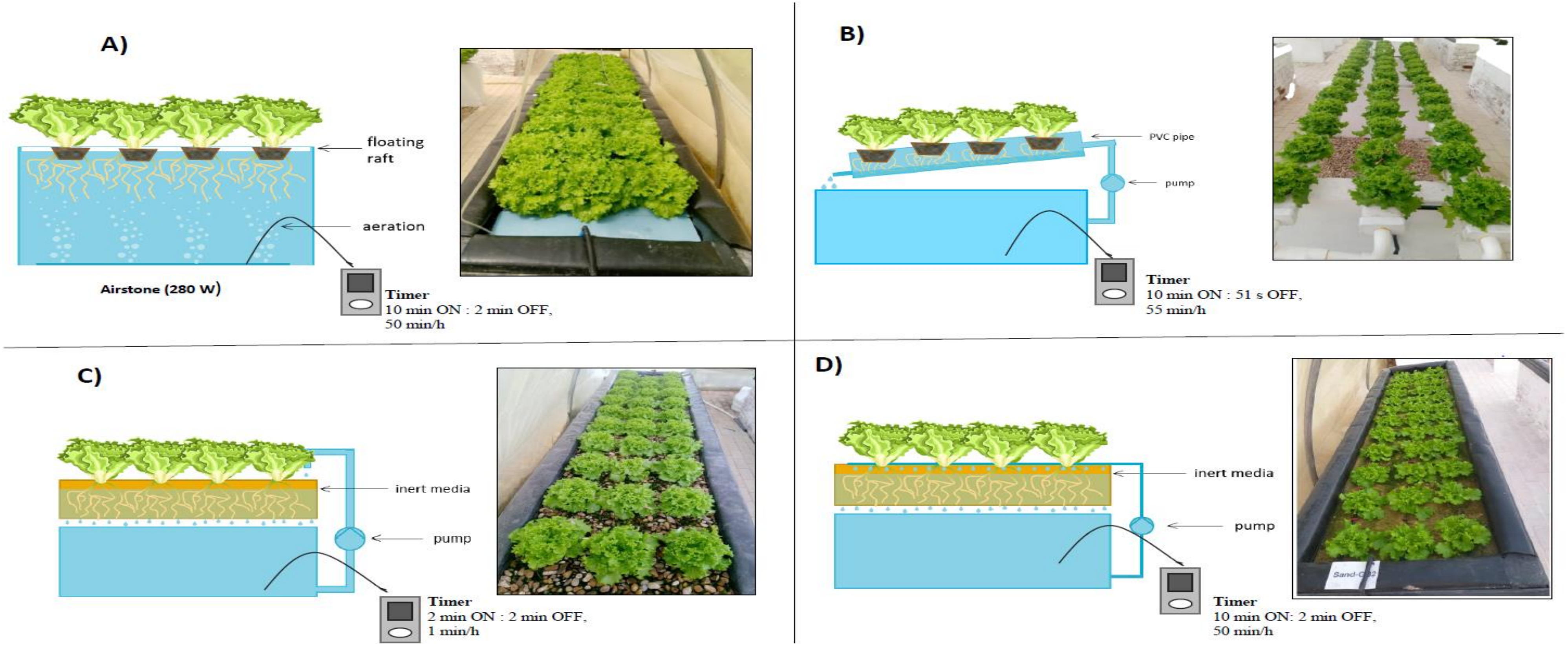
HYDROPONIC LAB-SCALE EXPERIMENTS

Subsystems



The various closed hydroponic sub-systems were tested for lettuce growth under different growing seasons. These systems: (A)- DWC: Deep Water Culture, (B)- NFT: Nutrient Film Technique, (C)- MB: Media- Bed system and (D)- SP: Sandponic

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HYDROPONIC LAB-SCALE EXPERIMENTS

Environmental conditions

Environmental factors	Optimum range
Air Temperature	15.5- 35 ˚C
Water Temperature	17-27 ˚C
Relative Humidity	27-88%
DO (Dissolved Oxygen)	6-8 ppm
pH	5.5 – 6.5
EC	1.5 - 2.5 dS m^{-1}
Photoperiod	Sun rise/ sun set time
Lighting	Recommended 15-17 mol/m^2/day. 300 µmol/m^{-2}/s^{-1}). shade cloth are used in summer time

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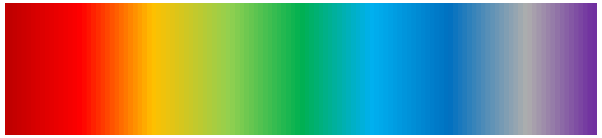
PARAMETERS

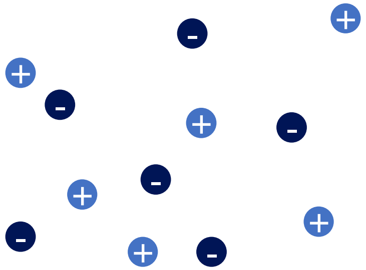
pH

Influences the availability of nutrients to the plants. Optimal pH systems of hydroponic (5.0-6.5) and aquaponic (6.0-9.0) systems differ.



Electrical Conductivity

Indicator for the amount of nutrients available in the nutrient solution. The EC value is maintained between 1.5 to 2.0 dS/m in Hydroponics, In aquaculture, the EC is less relevant.



Dissolved Oxygen

Essential factor for fish survival, and enhances nutrient uptake and defense mechanisms in plants.

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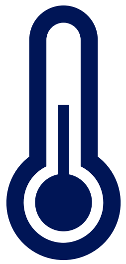
PARAMETERS

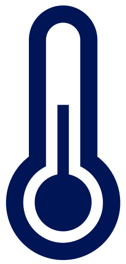
Water temperature

Optimal ranges depend on the natural environment of the farmed plants and fish.



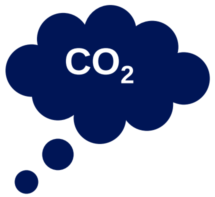
Air temperature

For fish only in so far relevant, as it might influence the water temperature.



Carbon dioxide (air)

High carbon dioxide concentrations in the air enhance plant growth, for the fish the concentration in the air is less relevant.



PARAMETERS

Light

Major factor for plant growth, depending on species requirements vary. For fish, light-dark-periods might have an impact.

Fertilization

An optimal nutrient ratio promotes healthy plant growth. The availability is affected by the pH and can be estimated via the EC. Less relevant for fish, as far as there are no toxins.

Ammonia

Critical substance in aquaculture due to high toxicity. In Aquaponics, the filters have to ensure sufficient Ammonia degradation. Less relevant for plant growth.

PARAMETERS

Feed

Both, composition and quantity are of importance. Depending on the fish species and age, feed and feeding differ.

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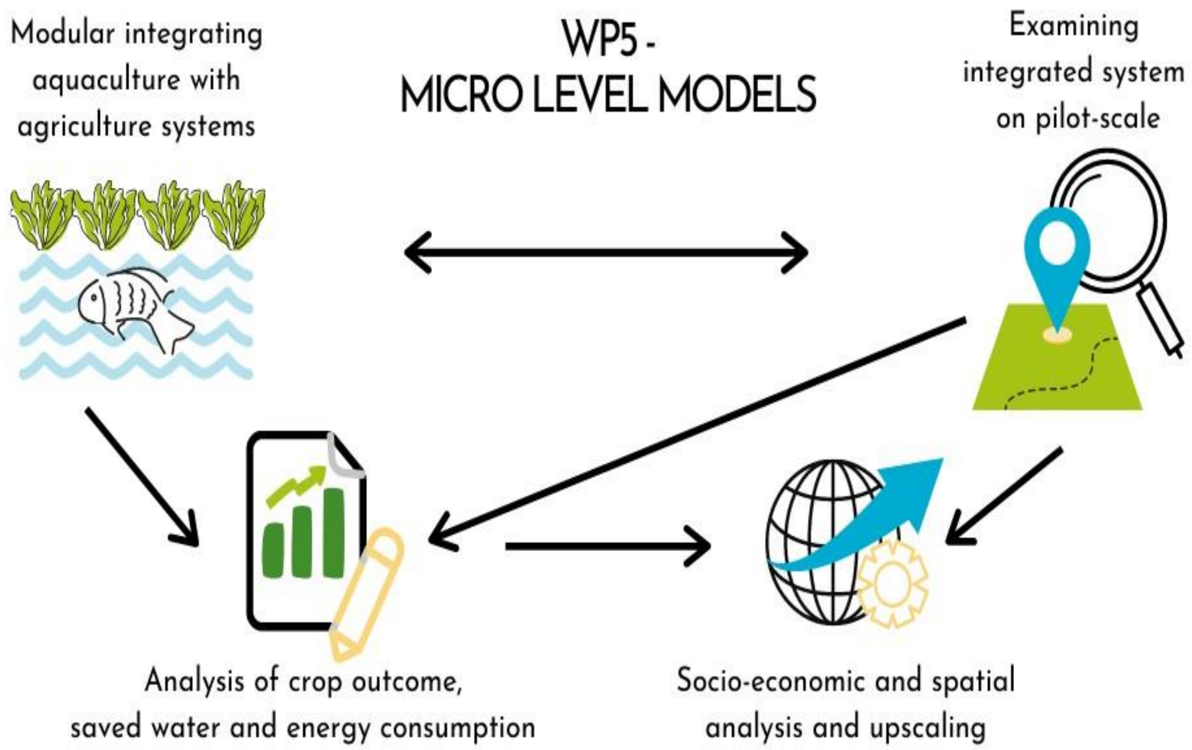
WP5 – MICRO LEVEL MODELS

Objectives

Demonstration of the **potential of new technological solutions** to **maximize water productivity** in terms of valuable products like **crops and fish**.

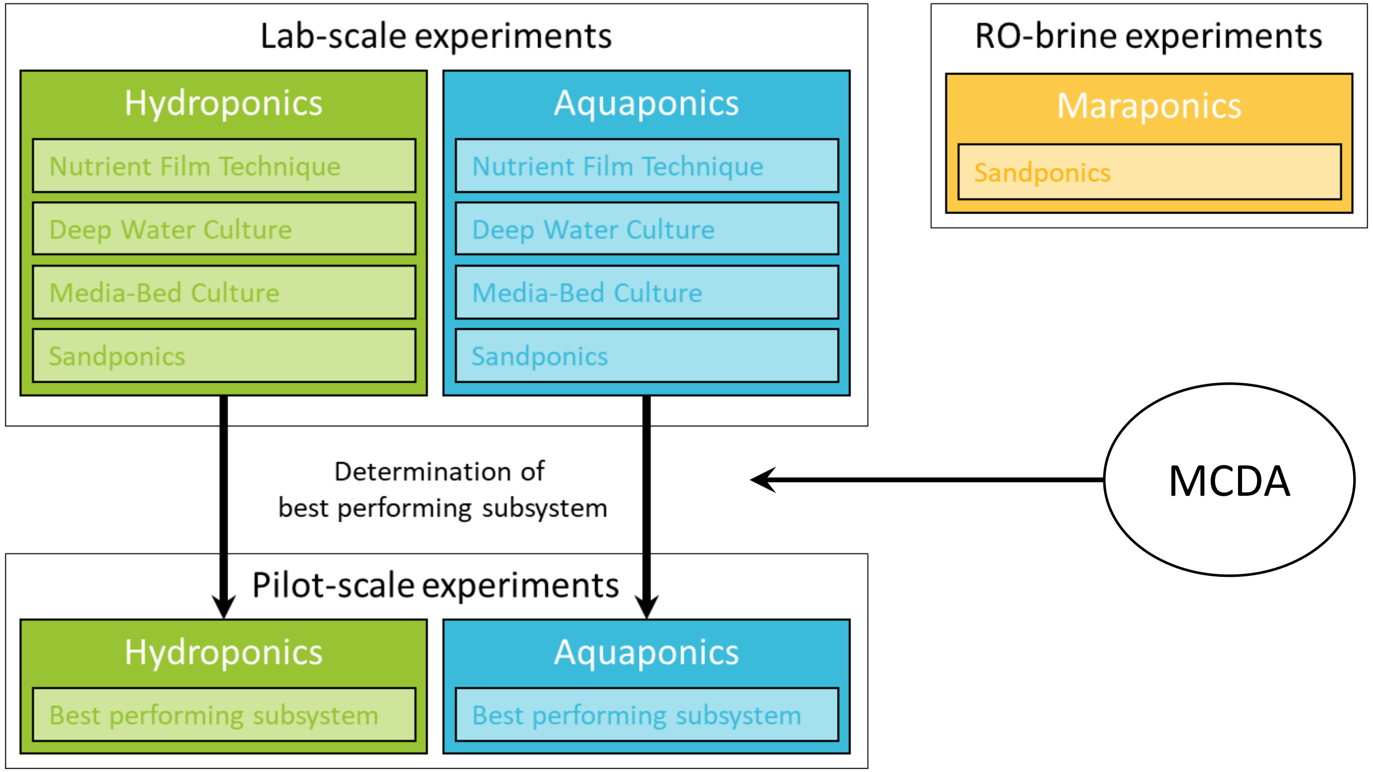
AWESOME KPI.4: increase in crop productivity per unit of water compared to standard agriculture.

Target: 8 times



WP5 – MICRO LEVEL MODELS

Overview of the experiments



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HYDROPONIC LAB-SCALE EXPERIMENTS

Measurements

- plant height
- stem diameter
- root length
- fresh head weight
- diameter of salad head
- Number of leaves
- Taste tests

On-site harvest measurements

- chlorophyll-content
- nutrient content
- dry weigth of head

Labaratory analysis

- Environmental parameter
- Water and power usage
- Capex and Opex costs recorded

Continous on-site measurements

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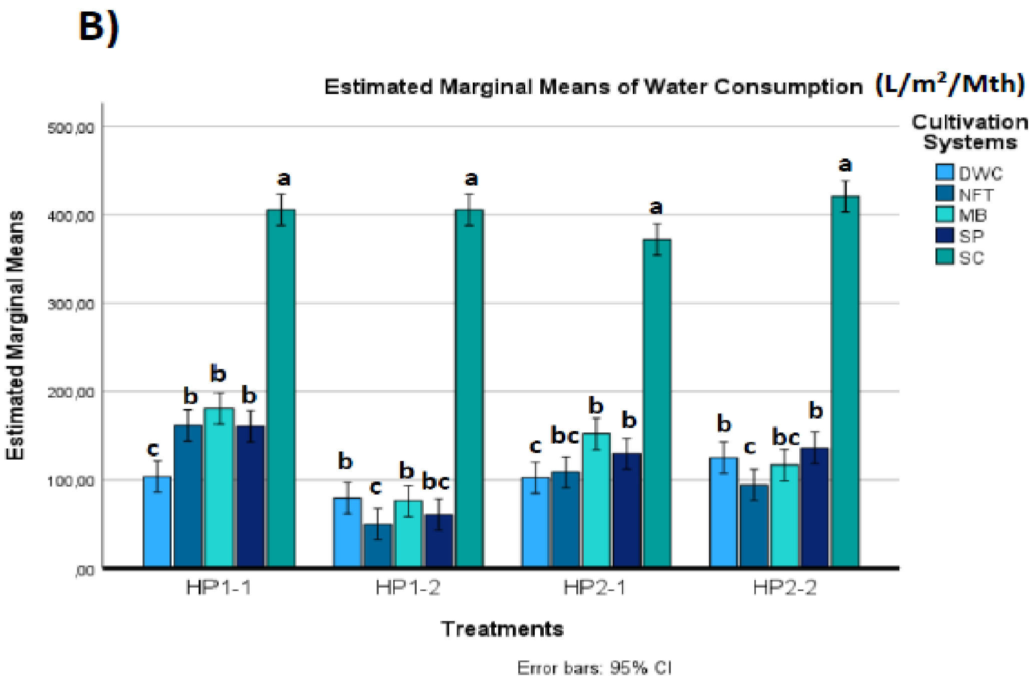
WATER-ECOSYSTEM-FOOD

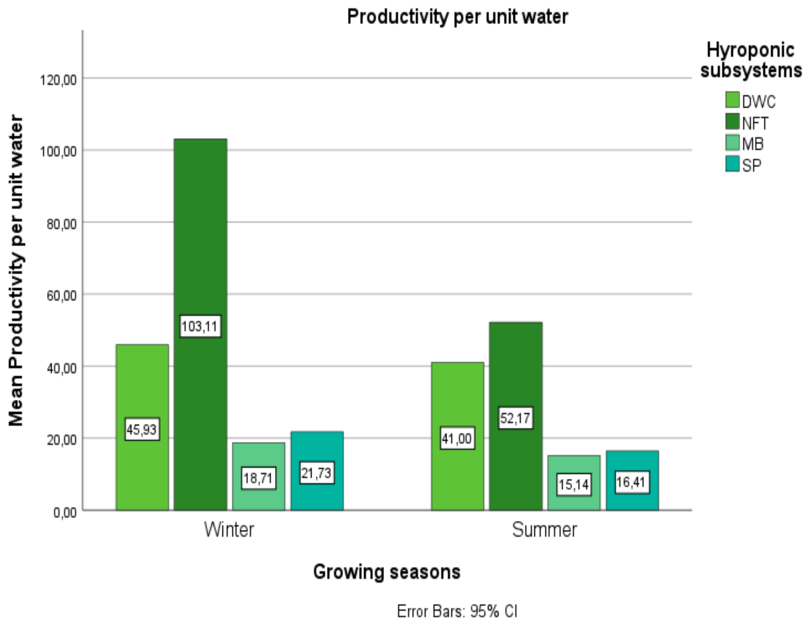
RESULTS

Water consumption



- A) Monthly lettuce productivity per unit (g/m²/Mth), B) monthly water consumption by plants per unit (L/m²/Mth). Cultivation systems: DWC: Deep water culture, NFT: Nutrient Film Technique, MB: Media- bed system and SP: Sandponic and SC: Soil- Based Cultivation

Productivity per Unit Water (kg/m³)



- Productivity per unit water (kg/m³). Hydroponic subsystems: DWC: Deep water culture, NFT: Nutrient Film Technique, MB: Media- bed system, and SP: Sandponic

TASTE TESTS

Sensory attributes and mean scores of lettuces grown under different cultivation systems

	Lettuce origins	Overall acceptability[1]	Apperance[1]	Overall flavor[1]	Aftertaste[1]	Sweetness[2]	Bitterness[2]	Color[2]	Crunnch iness[1]	Smell	Best lettuce
	DWC	8.76[a]	8.76[a]	9.0[a]	7.38[a]	4.57[a]	1.00[c]	4.57[a]	8.62[a]	29.60% fresh	52.4%
	NFT	8.95[a]	8.90[a]	9.19[a]	7.71[a]	4.67[a]	1.00[c]	4.62[a]	8.48[a]	29.60% fresh	47%
	MP	6.00[b]	6.00[b]	6.04[b]	5.10[b]	4.29[a]	1.57[b]	3.90[b]	6.29[b]	28.20% fresh. 7.1% neutral	-
T1 (n=21) F:8. M:13	SP	4.81[c]	4.95[c]	4.38[b]	3.19[c]	1.71[b]	3.86[a]	3.43[b]	5.71[b]	10.60 fresh. 92.9 % neutral	-

Sensory attributes of lettuces from hydroponic and soil-based cultivation are assessed independently. Lower case letters within each main treatment indicate significant differences after the least significant difference (LSD) post hoc test (significance level $p< 0.05$ and $p< 0.01$, not significantly at $p\geq 0.05$) for each parameter. Smell and best lettuce preference are expressed as a percentage. Cultivation systems: HP: hydroponic subsystems. Lettuce origins: DWC: Deep water culture. NFT: Nutrient Film Technique. MB: Media-bed system, SP: Sandponic, N: number of testers, gender of testers, F: female, M: male.

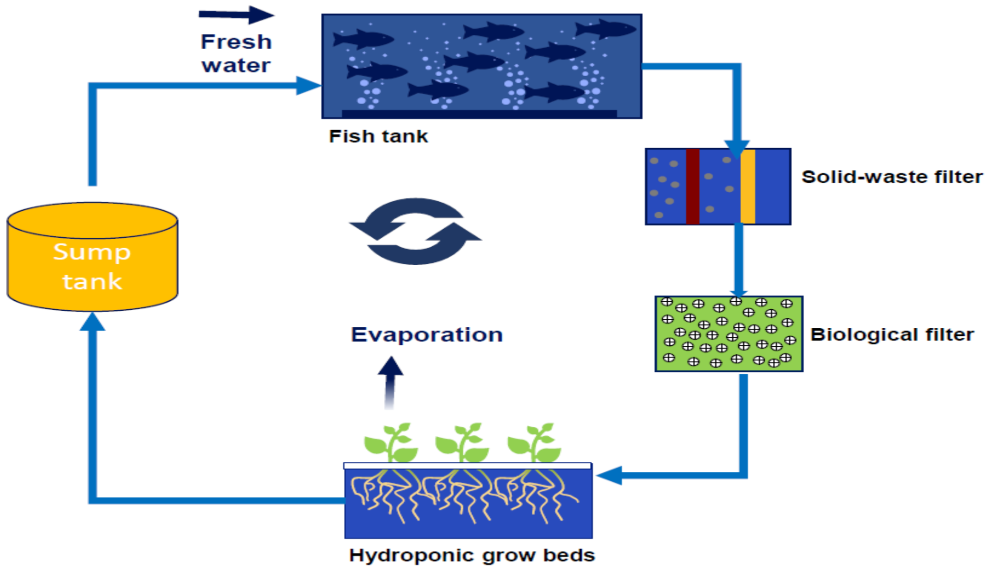
[1] Evaluated with a 10-point scale: 1 = dislike extremely; 10 = like extremely,

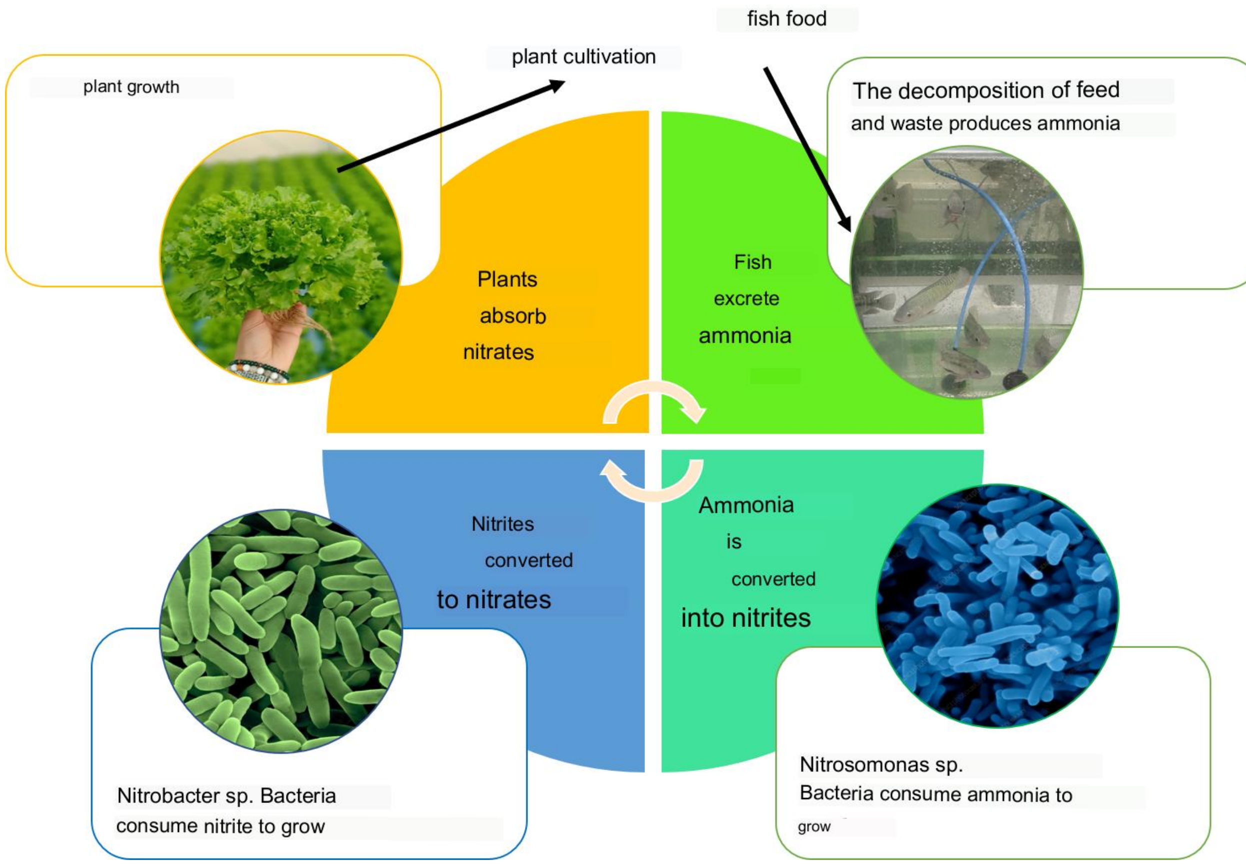
[2] Evaluated with a 5-point scale: 1 = not at all bitter or sweet; 5 = extremely bitter or sweet

INNOVATIVE AQUACULTURE TECHNIQUES

Recirculating Aquaculture System

Waste water of the aquaculture is treated with biological and mechanical filters and recirculated, instead of being discharged.





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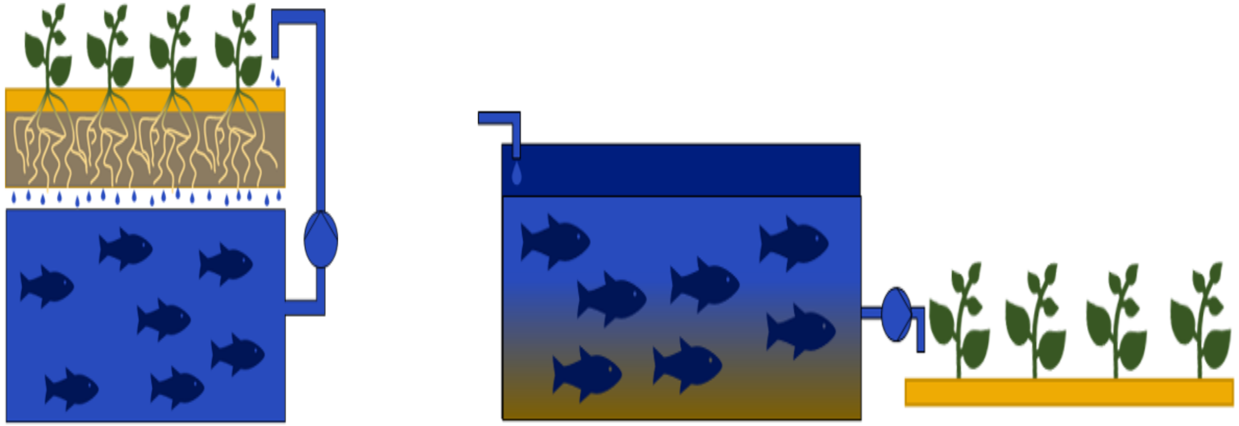
Aquaponic systems

A) B)

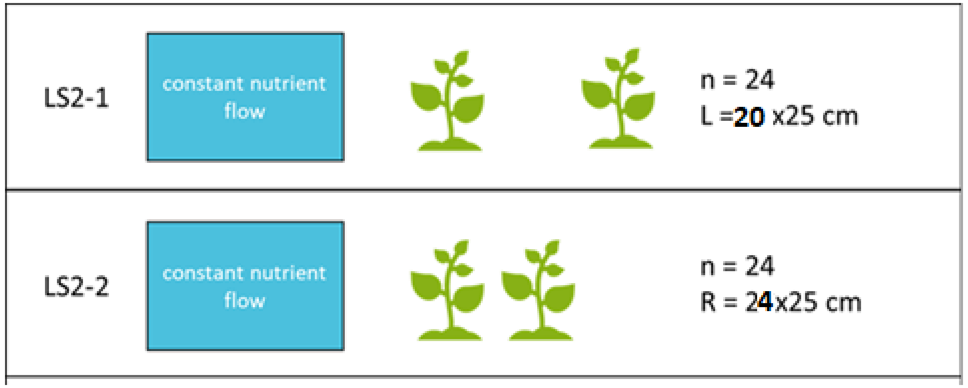


Sandponic system

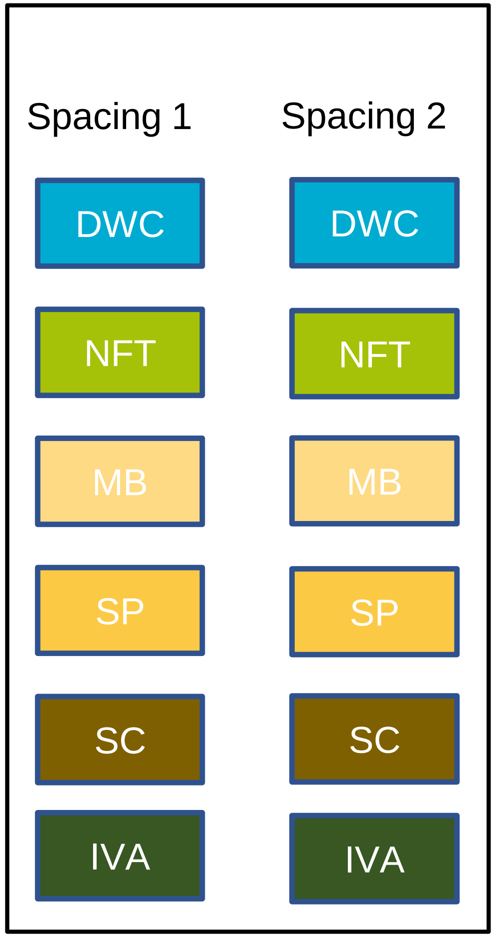
- Aquaponic system design with media without adding any mechanical and biological filter (MB and SP), B- and Integrated Vegetable Aquaculture (IVA) design.

AQUAPONIC EXPERIMENTS

Experimental design



- Experiments in the AWESOME lab-scale aquaponics setup. In these experiments, planting spacing is tested. Nutrient flow from the fish tanks is kept constant (adjusted by feeding and fish density)



- Cultivation systems: DWC: Deep water culture, NFT: Nutrient Film Technique, MB: Media-bed system, SP: Sandponic, IVA: Integrated Vegetable Aquaculture and SC: Soil Cultivation

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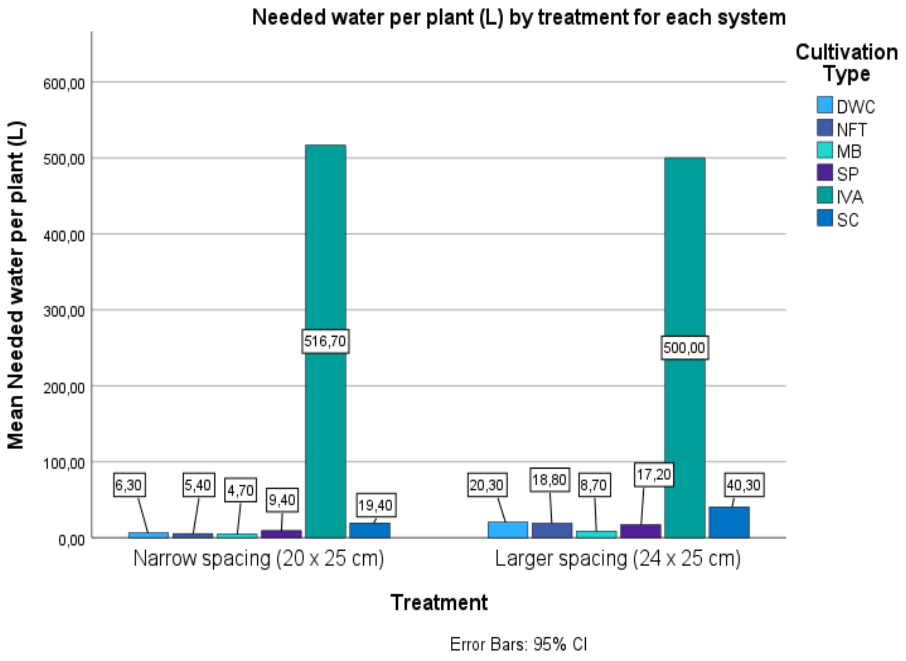
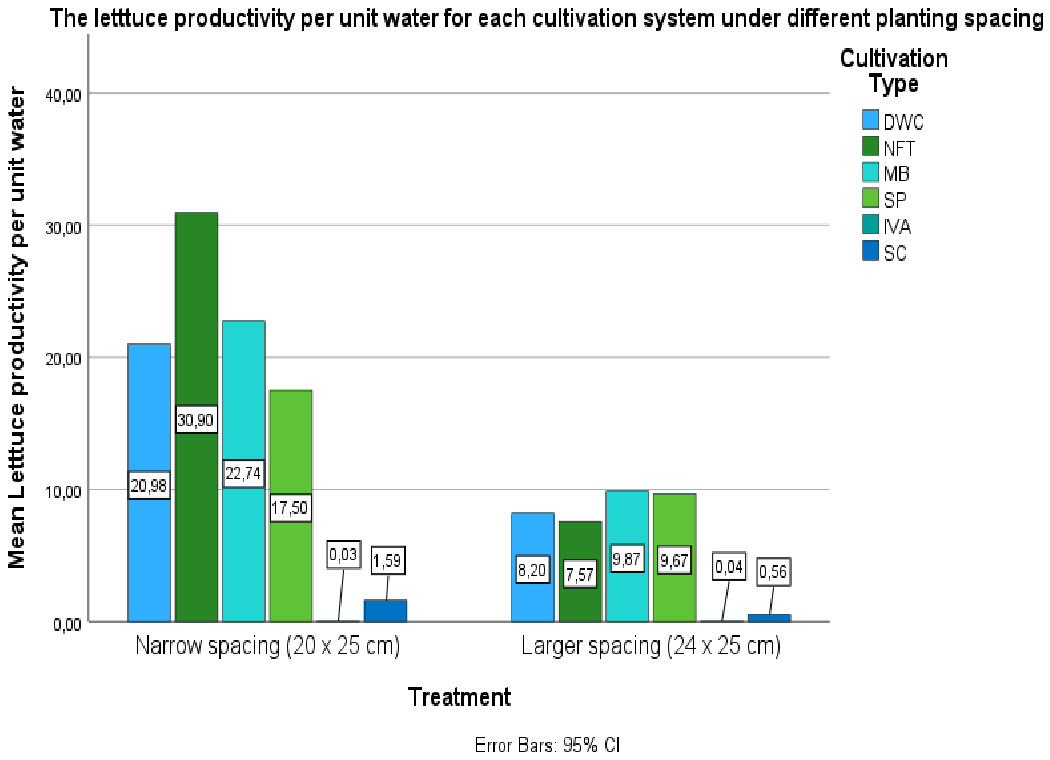
RESULTS

Needed water per plant



Lettuce productivity per unit water



- Needed water per plant and lettuce productivity per unit of water in several aquaponic systems: Cultivation systems: DWC: Deep water culture, NFT: Nutrient Film Technique, MB: Media-bed system, SP: Sandponic, IVA: Integrated Vegetable Aquaculture and SC: Soil Cultivation with different planting spacings.

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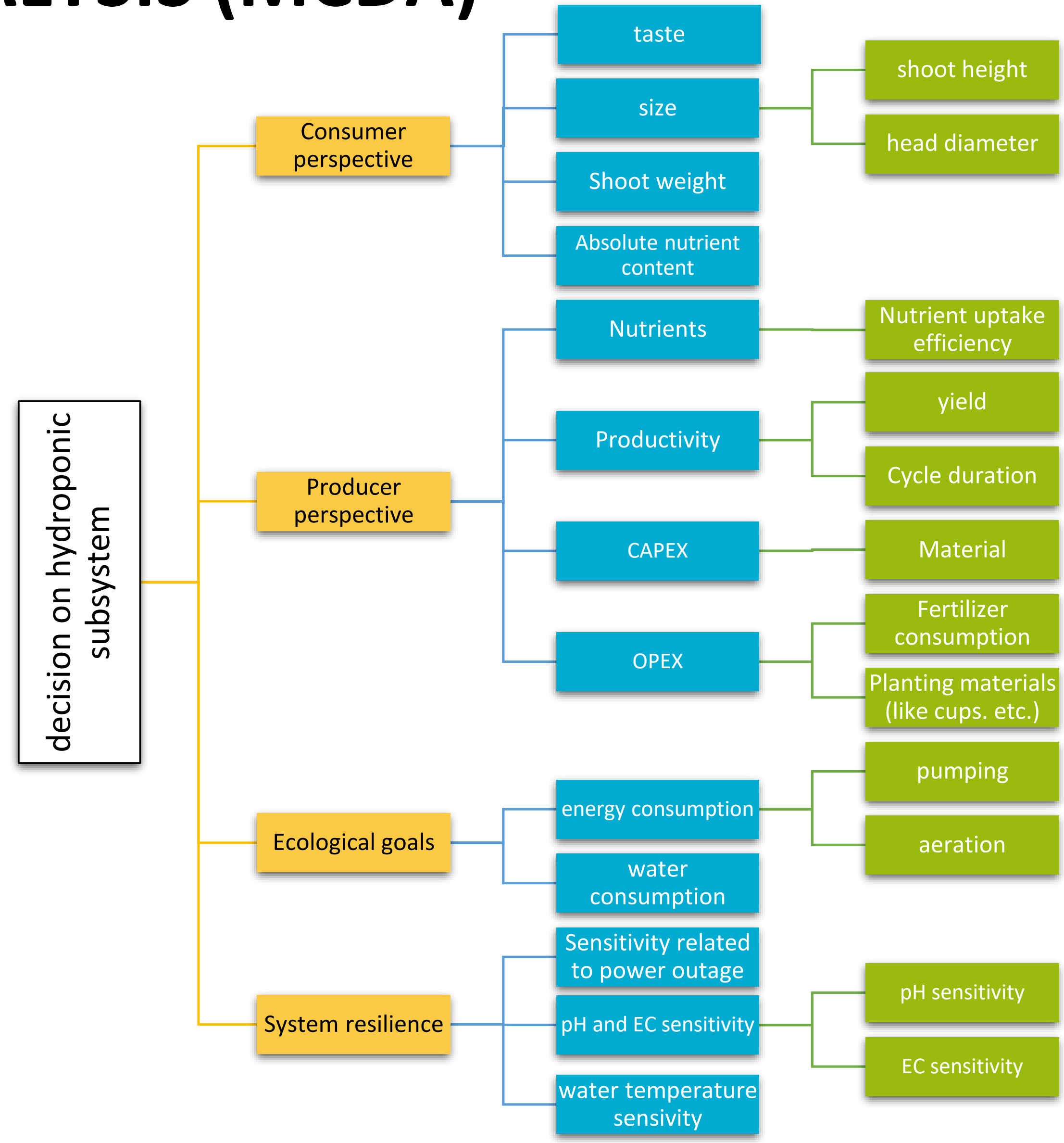
MULTI-CRITERIA DECISION ANALYSIS (MCDA)

Considered Criteria

- Selection of criteria clustered into the groups ´´consumer perspective“, ´´producer perspective“, ´´ecological goals“ and ´´system resilience``.



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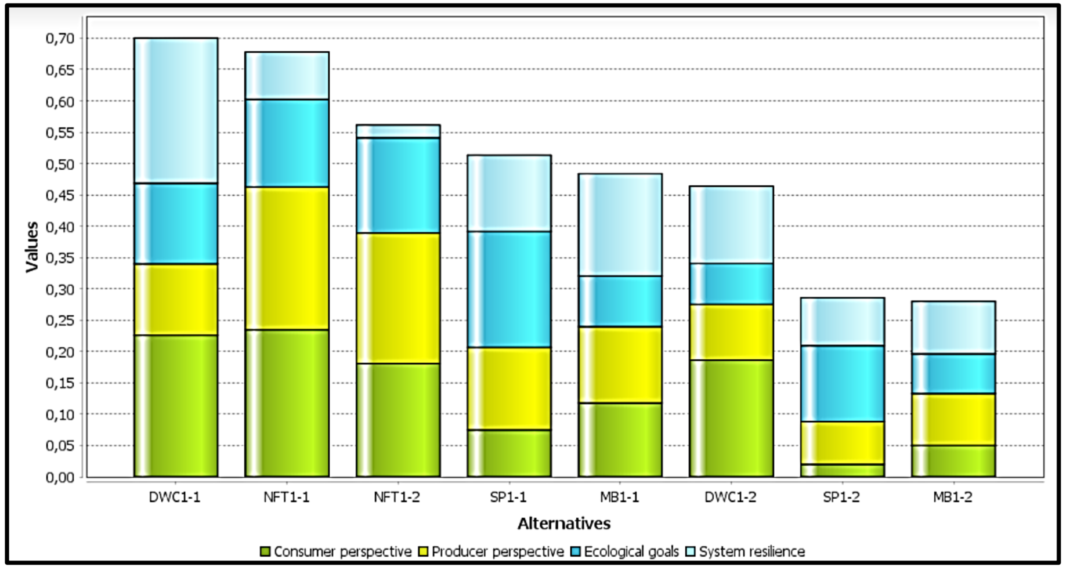
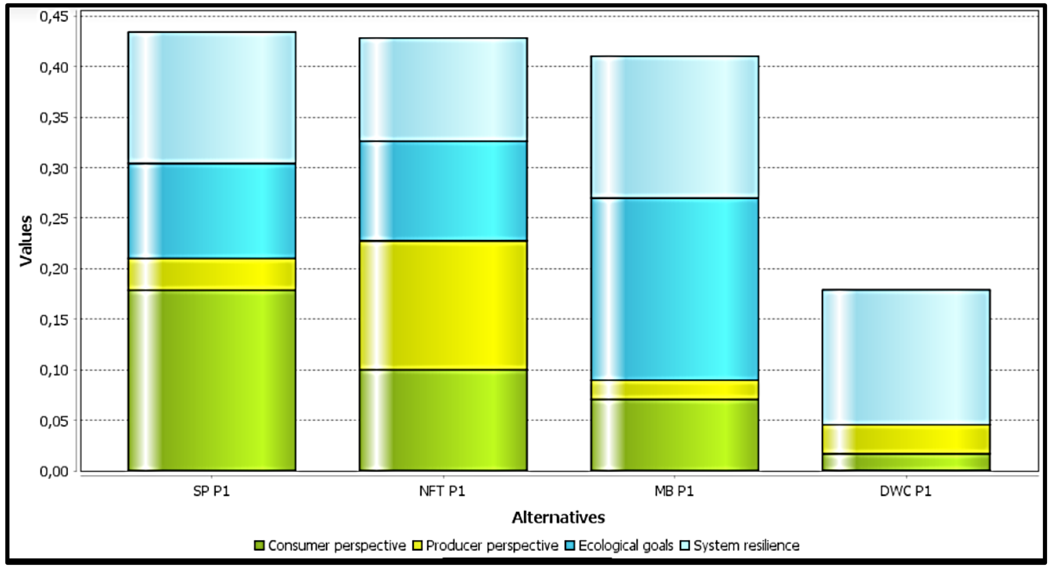
MULTI-CRITERIA DECISION ANALYSIS (MCDA)

Hydroponic Experiments



Aquaponics Experiments



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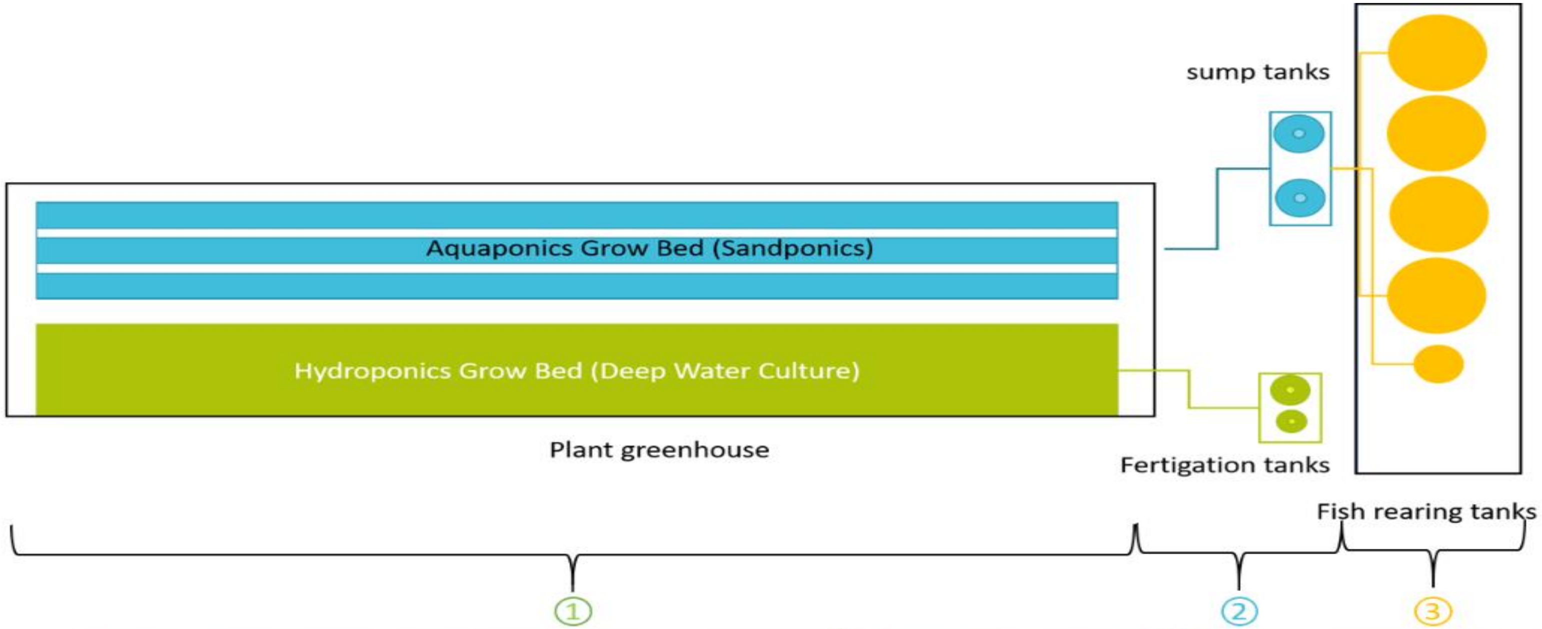
PILOT-SCALE EXPERIMENTS

PRIMA
IN THE MEDITERRANEAN AREA



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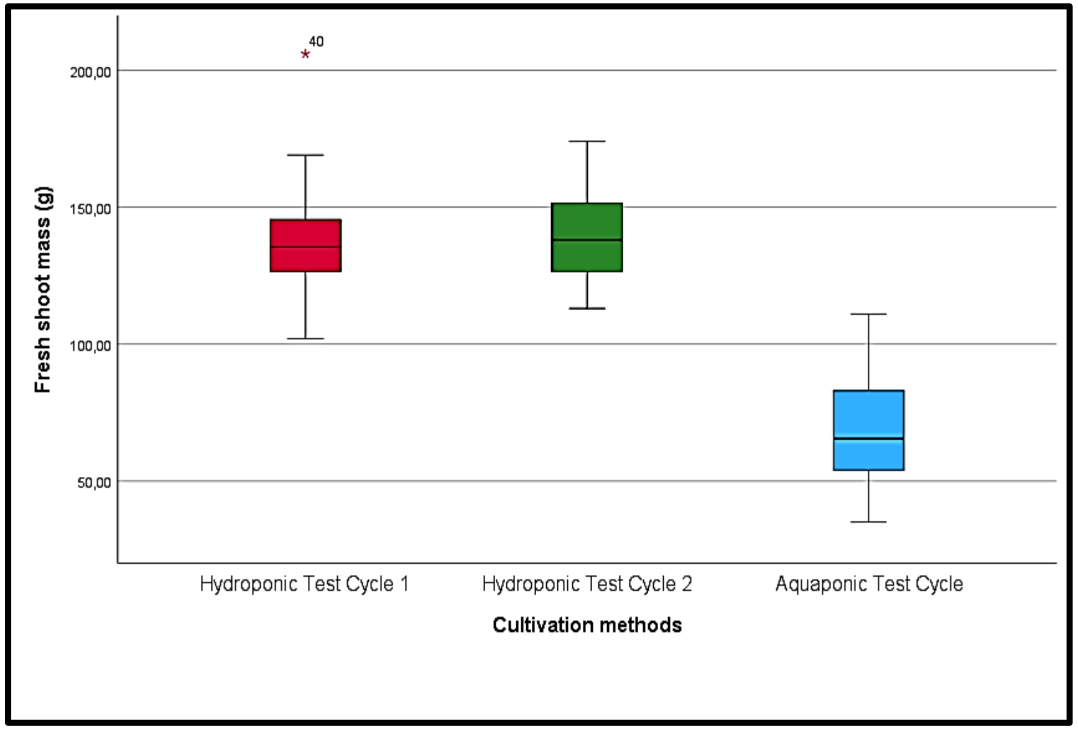
1.Pilot scale Deep Cater Culture (DWC) hydroponicon the left side, sandponics gow bed on the right side, 2. fertigation and sump tanks , 3. fish rearing units

PILOT-SCALE EXPERIMENTS

Productivity in pilot scale experiments



Nutritional and Antioxidant Values

Nutrient value	Chlorophyll A	Chlorophyll B	Carotene	Vitamin A	Vitamin C
Our findings (mg/100 g)	21. 09	29. 05	38.6	0.24 = 799, 9 IU	5.59
Nutrient Data Base from reference (mg/100 g)	20.53	6.44	20.4 -40.6	0.09 =330 IU	4.2 ±0.7
References	Lei & Engeseth (2021)	Lei & Engeseth (2021)	Mou (2005)	Mou & Ryder (2002)	Llorach et al. (2008)

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ECONOMIC FACTORS

The comparation for efficiency of lettuce mass production from hydroponic (HP) and aquaponic systems (AP) at pilot scale

Hydroponic systems		**Aquaponic systems**	
Total lettuce yield for a month	1590 *157.5=250.4 kg	Total yield for a month	1630*112=182.56 kg
Total lettuce yield for a year	3005.1 kg	Total yield for a year	2190.72
Yearly gain	€5559.43=1.85 €*3005.1	Yearly gain	4052.83=1.85*2190.72
Total monthly fish production	0	Total monthly fish production	27.19 kg
Total annual fish production	0	Total annual fish production	326.28 kg
Yearly gain	€5559.43	Yearly gain	€701,52
Total yearly gain from food production	€5559.43	Total yearly gain from food production	€ 4754,35
CAPEX	7.570,29	CAPEX	17.396,94
Total yearly OPEX	3.146,04	Total yearly OPEX	10.185,01
Total costs:	10.716,33	Total costs:	27.581,95
$ROI_{hydroponic}$	51.83%	$ROI_{aquaponic}$	31.25 %
$Payback_{hydroponic}$	1.36 years	$Payback_{aquaponic}$	3.66 years

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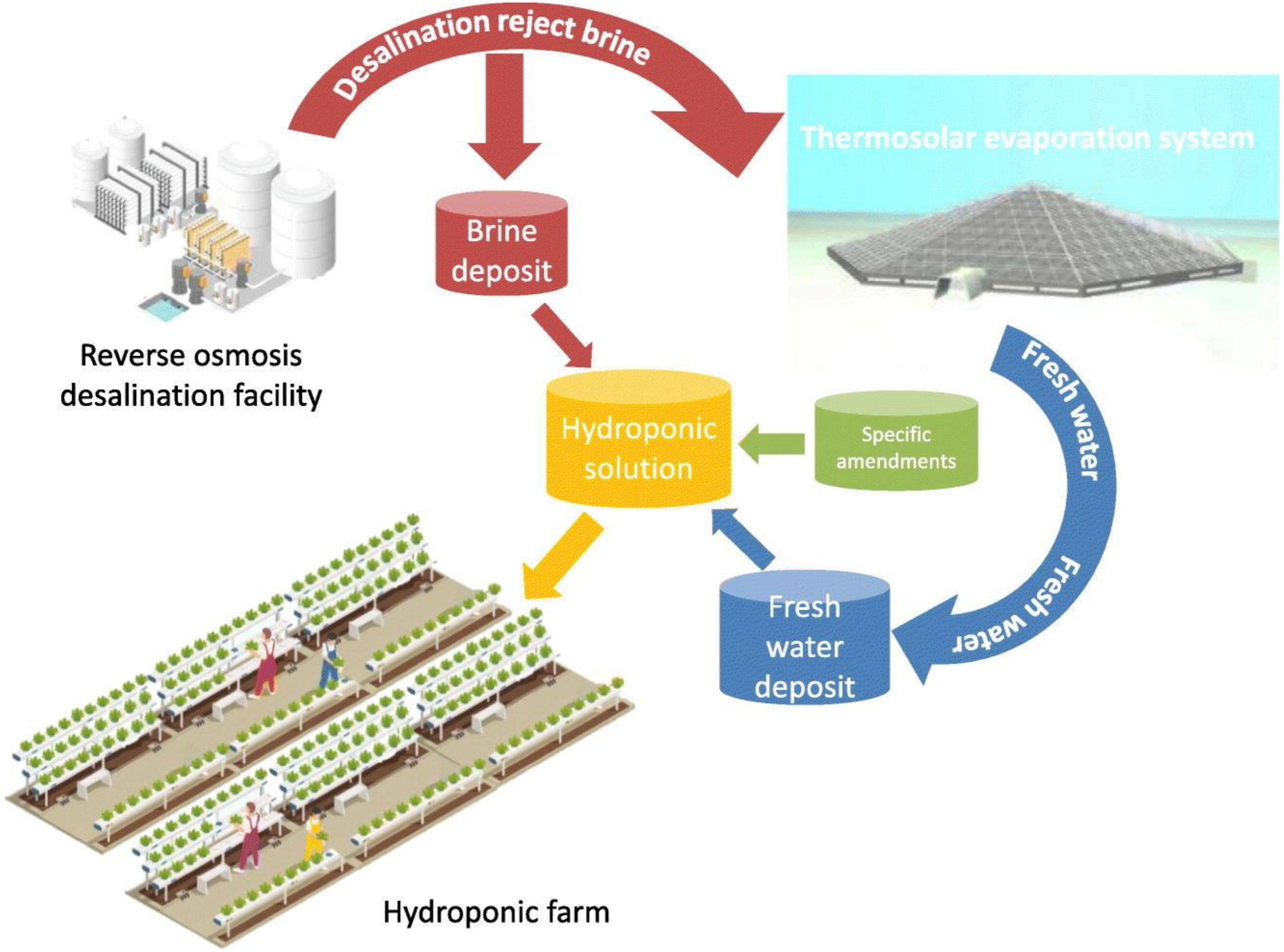
BENEFITS

Soilless systems

- Less pesticides are used
- need shorter time for cultivation
- Parameters are adjustable for optimal plant growth

APPLICATIONS IN SOILLESS SYSTEMS
Soiless cultivation using desalination technology



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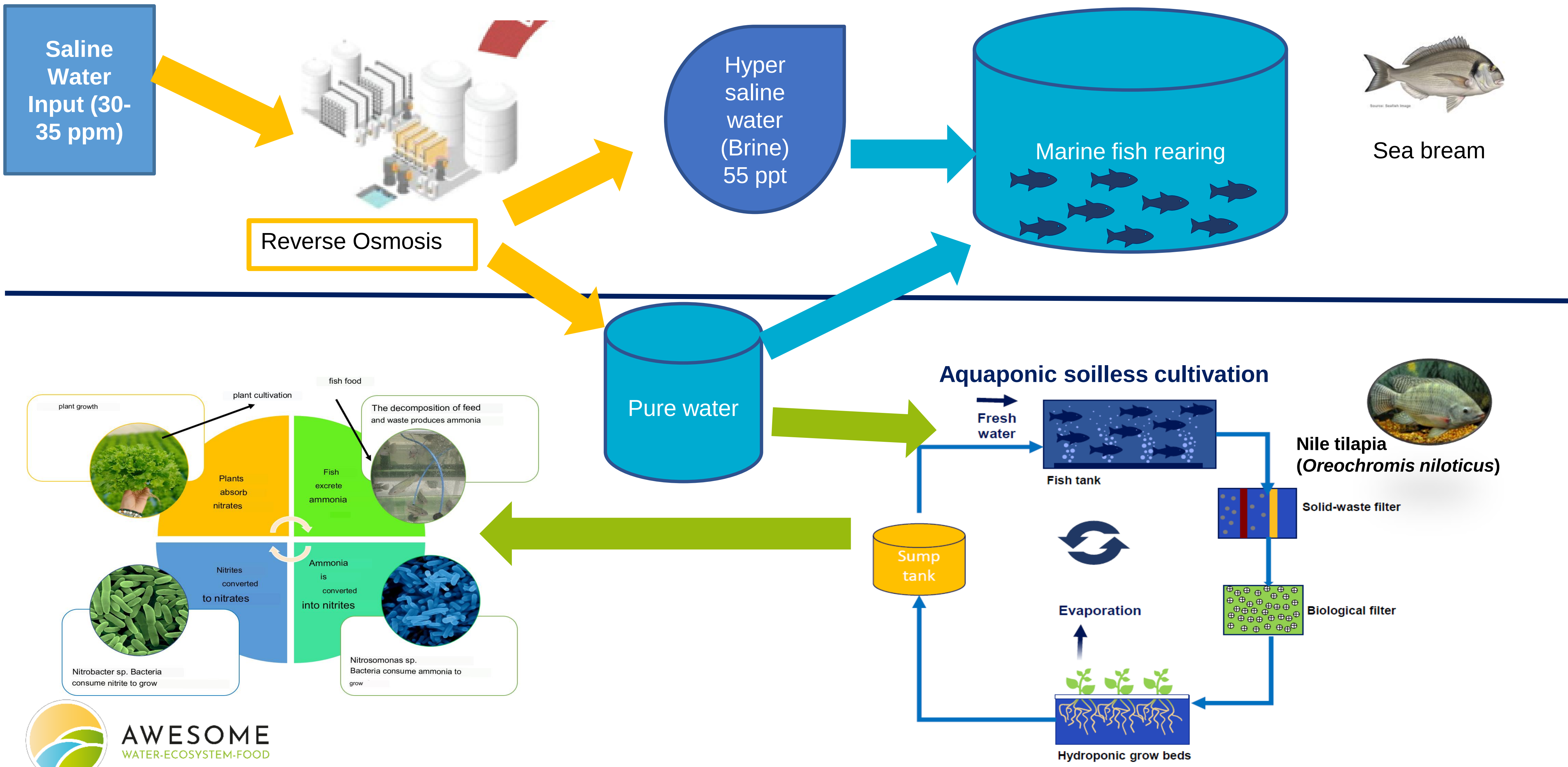
Food Productivity Per Unit Desalinated Water



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ENERGY REQUIREMENT

The effect of solar radiation on the growth and development of hydroponically grown lettuce in two areas with different climates

Jonathan Kummer[1] • Demet Çekin[1] • Hani Sewilam[1]

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Please cite this paper as follows:
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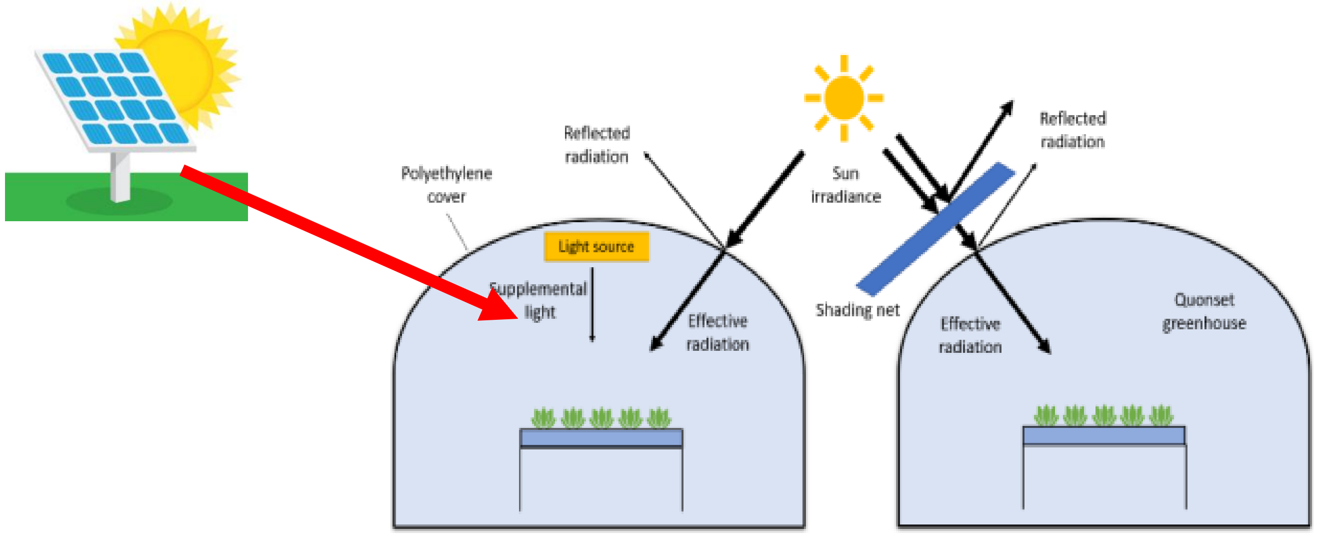


Lighting balance using tools supplemental light and shading net in greenhouse in two different season for lettuce growth (left: winter, right: summer)

Daily light integrals for Aachen and Cairo in 2019, 2020, and needed energy (mol/m²/d).

Months	Aachen 2019	Aachen 2020	Available DLI	Difference	Cairo 2019	Cairo 2020	Available DLI	Difference
Jan	3,23	4,08	3,11	13,89	33,73	32,08	27,97	10,97
Feb	15,27	5,02	8,62	-8,38	41,38	40,62	34,85	17,85
Mar	13,91	23,69	15,98	-1,02	56,04	56,75	47,94	30,94
Apr	36,1	53,39	38,03	21,03	70,89	73,49	61,36	44,36
May	31,37	55,86	37,07	20,07	83,59	85,04	71,67	54,67
Jun	56,52	42,04	41,89	24,89	84,12	90,42	74,18	57,18
Jul	40,84	36,85	33,02	16,02	81,44	85,66	71,02	54,02
Aug	38,66	35,21	31,4	14,4	74,04	79,25	65,15	48,15
Sep	23,73	28,69	22,28	5,28	0	58,99	58,99	41,99
Oct	8,49	6,38	6,32	-10,68	0	53,12	53,12	36,12
Nov	5,05	8,86	5,92	-11,08	41,92	37,30	33,67	16,67
Dec	3,04	2,37	2,3	-14,7	34,12	32,12	28,15	11,15

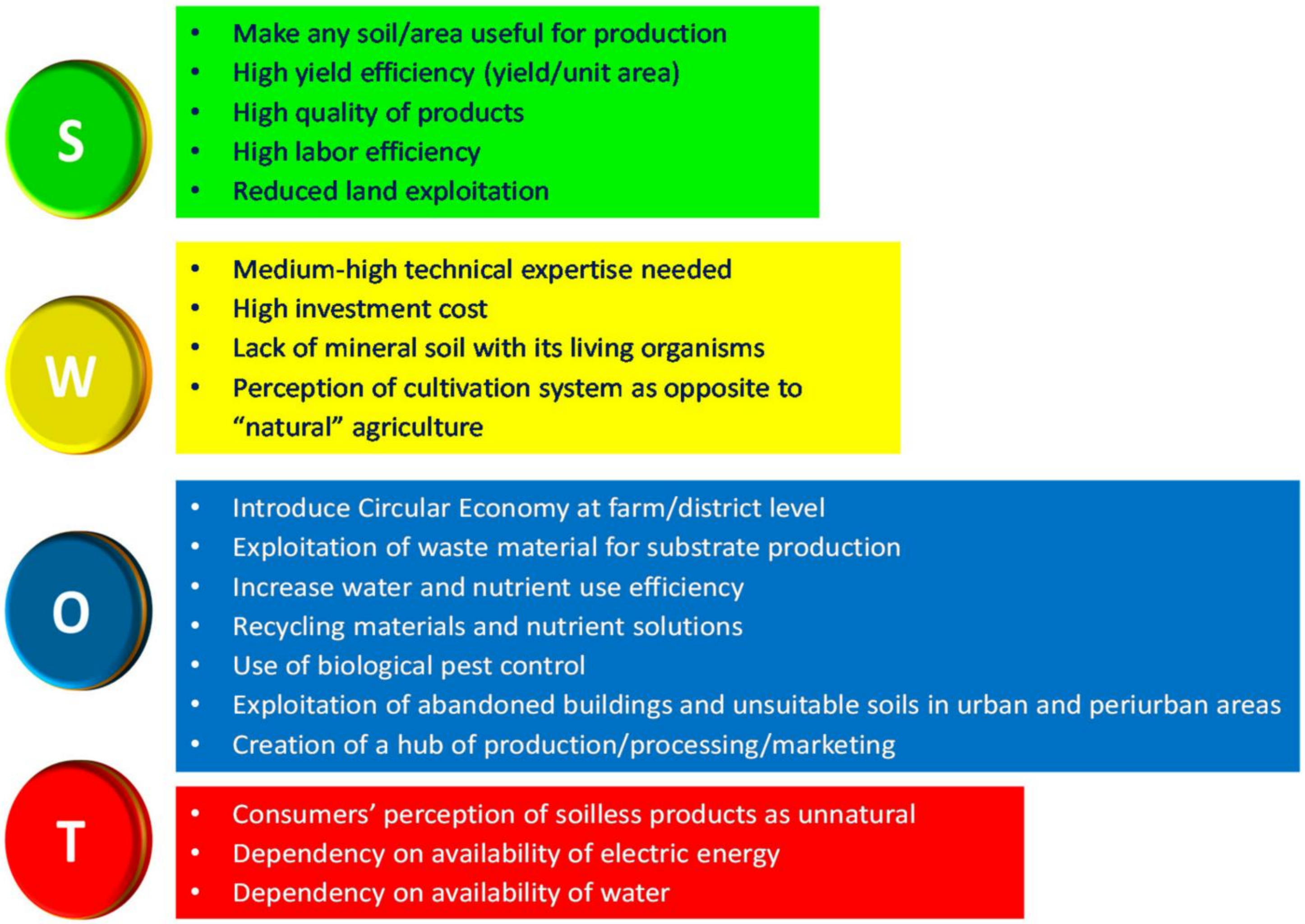
Light balance tools overview for Aachen and Cairo. Supplemental light duration in hours per day, Power in kWh per lamp per month, and Shading factors in percent

Months	Supplemental light duration	Power	Shading factors Aachen	Shading factors Cairo
Jan	13.4	166.1	0	39.22
Feb	8.08	100.1	0	51.22
Mar	0.98	12.1	0	64.54
Apr	0	0	55.3	72.29
May	0	0	54.1	76.28
Jun	0	0	59.4	77.08
Jul	0	0	48.5	76.06
Aug	0	0	45.8	73.91
Sep	0	0	23.7	71.18
Oct	10.3	127.7	0	68
Nov	10.69	132.5	0	49.51
Dec	14.18	175.8	0	39.61

Supplemental light duration in hours per day, Power in kWh per lamp per month, and Shading factors in percent

AWESOME
WATER-ECOSYSTEM-FOOD

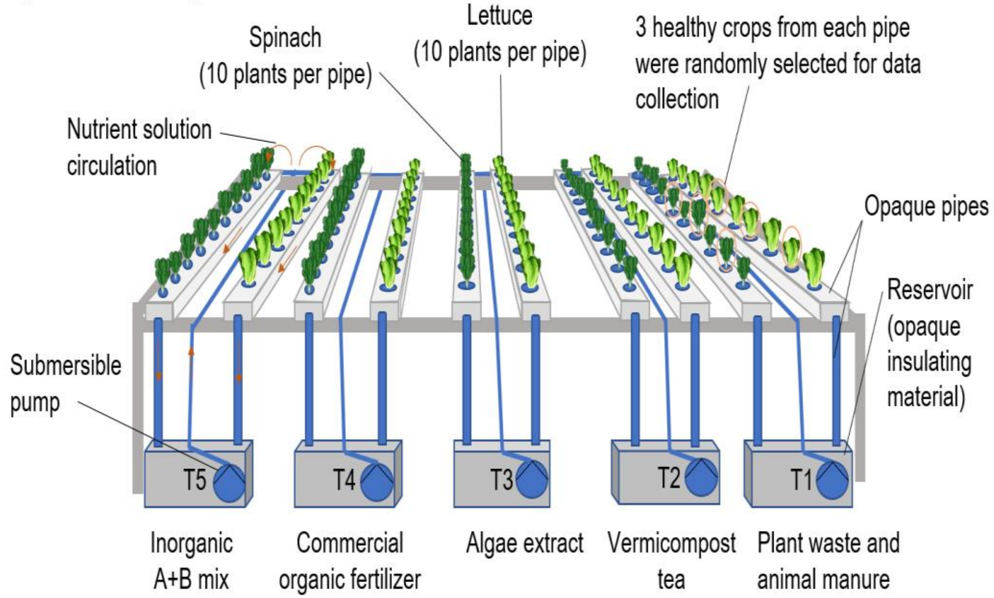
BENEFIT-COST TRADE-OFFS OF SOILESS SYSTEMS



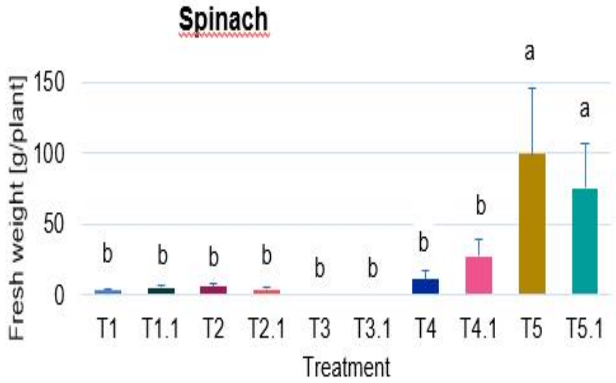
SWOT analysis related to the adoption of soilless systems in horticultural production. S, strengths; W, weaknesses; O, opportunities; T, threats (Gonella and Renna, 2021)

USE OF ORGANIC FERTILIZERS IN HYDROPONIC SYSTEMS

Experimental design

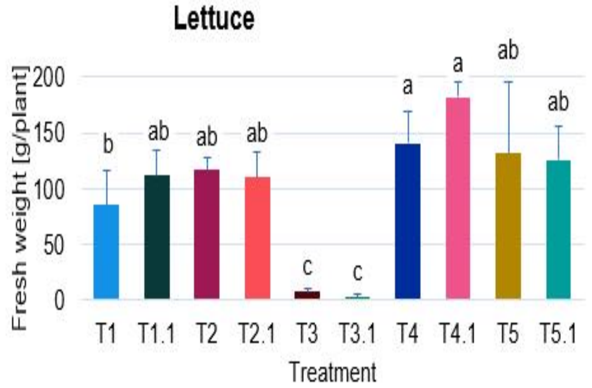


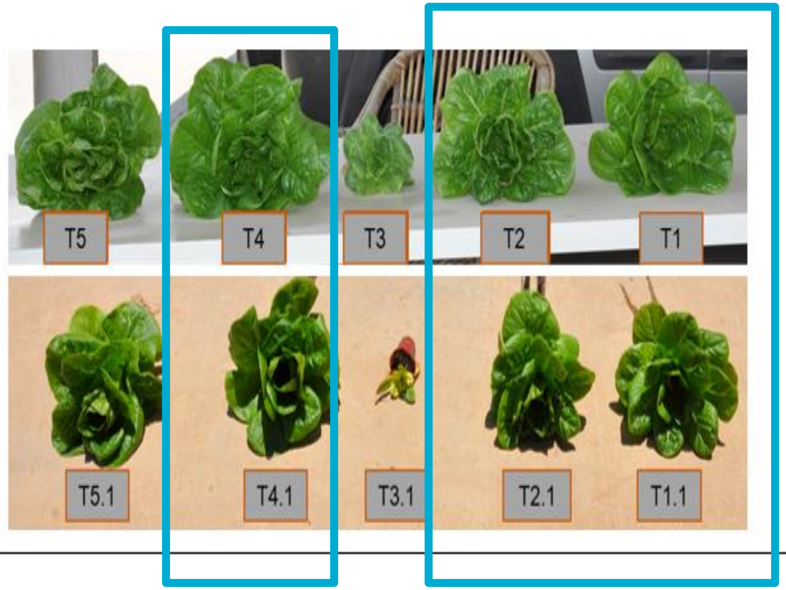
Effects of different treatments on biomass yield of spinach and lettuce



Treatments

- Plant waste + animal manure
- P.A Foliar spray
- Vermicompost tea
- V.T Foliar spray
- Algae extract
- A.E Foliar spray
- Commercial organic fertilizer
- C.O.F Foliar spray
- Inorganic fertilizer (A+B)
- A+B Foliar spray



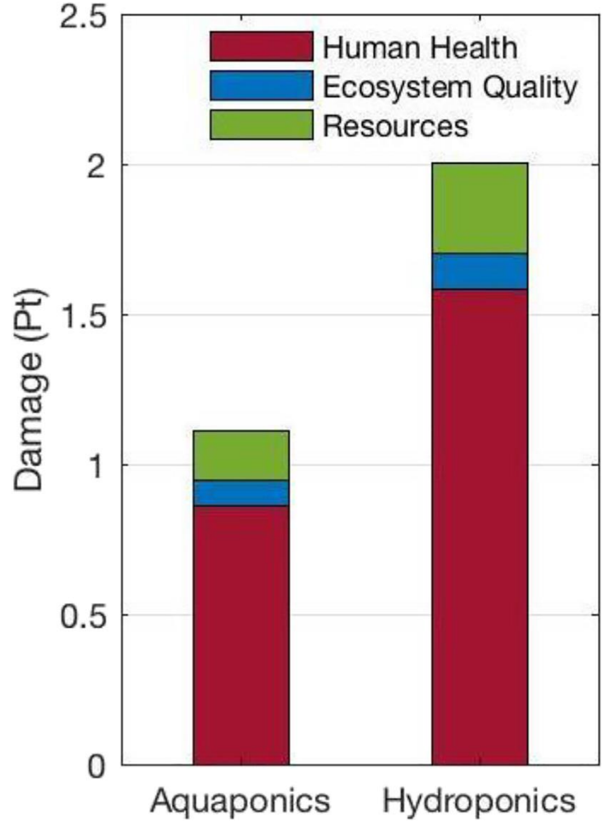


AWESOME
WATER-ECOSYSTEM-FOOD

Ecological footprints

Agricultural system	Conventional system	Hydroponic system	Aquaponic system
Production (ton/y)	51.150	416.448	416.448
Land (m^2/t)	195.503	24.013	24.013
Water (m^3/t)	123.33	17.225	35.058
N (kg/t)	5.572	2.132	2.132
P (kg/t)	1.892	0.237	0.237
K (kg/t)	4.982	2.369	2.369
Energy (MJ/t)	1175	136270	70200
Carbon (kg CO_{2eq}./t)	109.110	7.953.931	5.466.591
Waste (L/t or t/t)	_	1099.747 (L/t)	0.8 (t/t)
Total	318.234	8.135.940	5.600.363

Comparison between the endpoint environmental impacts (single score) of aquaponics and hydroponics



AWESOME
WATER-ECOSYSTEM-FOOD

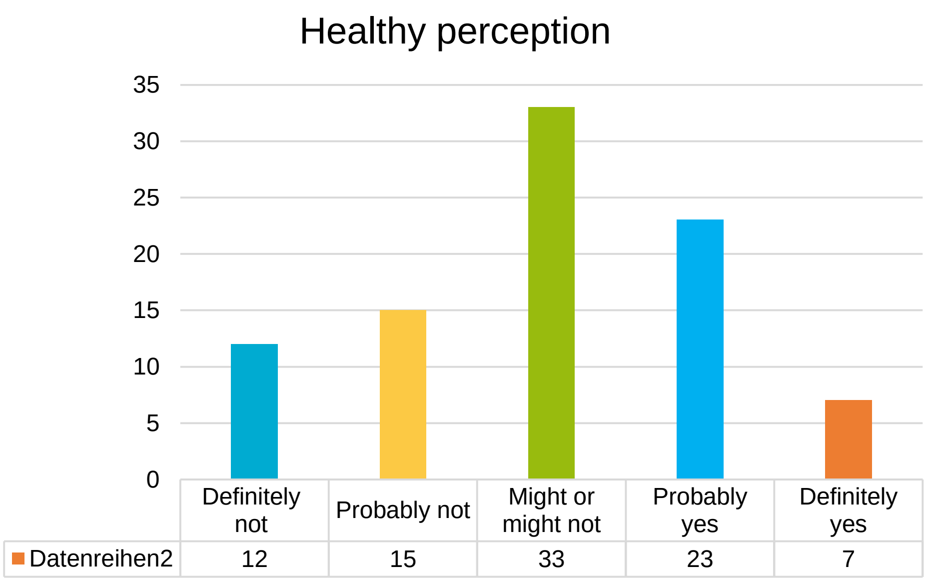
Hamster shoppings

Sustainability- Green recovery

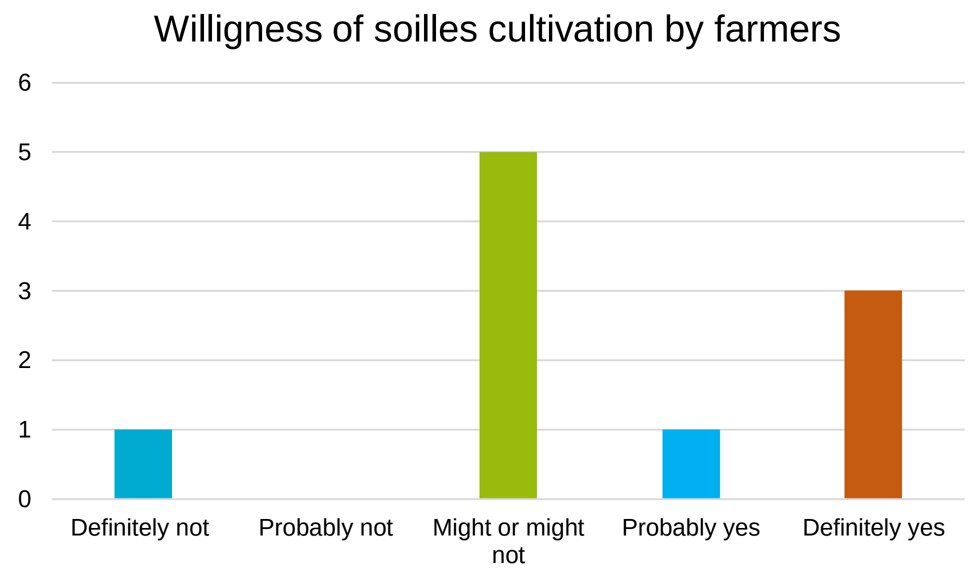
By anticipating that food systems will not be able to withstand crises such as the COVID-19 pandemic if they are not sustainable, the European Commission published a combined evaluation roadmap and inception impact assessment of activities for this implementation on 29 May 2020. It will also support a green recovery following the Covid-19 pandemic

Socio-economic Aspect

Do you think products produced by soilless agriculture are healthy?



Do you want to join some seminars/ courses for a new cultivation method?



Sustainability- Green recovery

- The Framework of Directive 2009/128/EC, that is directive on the sustainable use of pesticides which aims to manage a sustainable use of pesticides in the EU.- Integrated pest managemet

- This framework has been adopted by taking account of the Biodiversity strategy for 2030 and the Farm to Fork Strategy which are aiming to make food systems fair, healthy and environmentally-friendly, and to recover biodiversity of EU states by 2030.

ECOLOGICAL ASPECT

IPDM Strategies in soilless systems

Common disease and pests

Diseases in soilless systems

IPDM Steps

use of pesticides, mineral fertilisers in different systems

FACTORS AFFECTING THE CULTIVATION

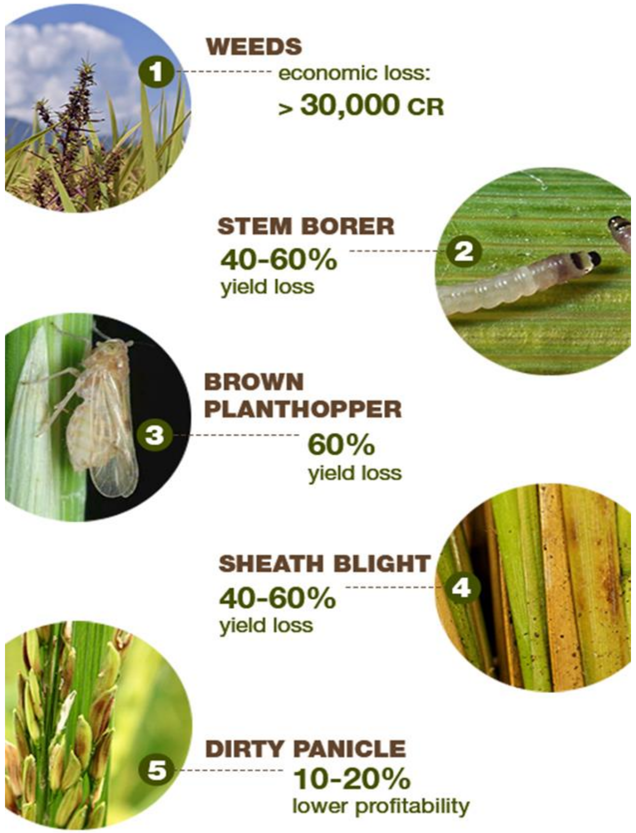
Reduce in yield and quality of crops

- abiotic stressors
- biotic factors

BIOTIC FACTORS

Unwanted guests

- Weeds, pests and plant pathogens can lead to economically losses



Are diseases and pests still found in soilless farming?

- No soil-borne pests and diseases
- Other plant pathogens and pests can greatly reduce overall production.
- Diseases can easily spread from one plant to another

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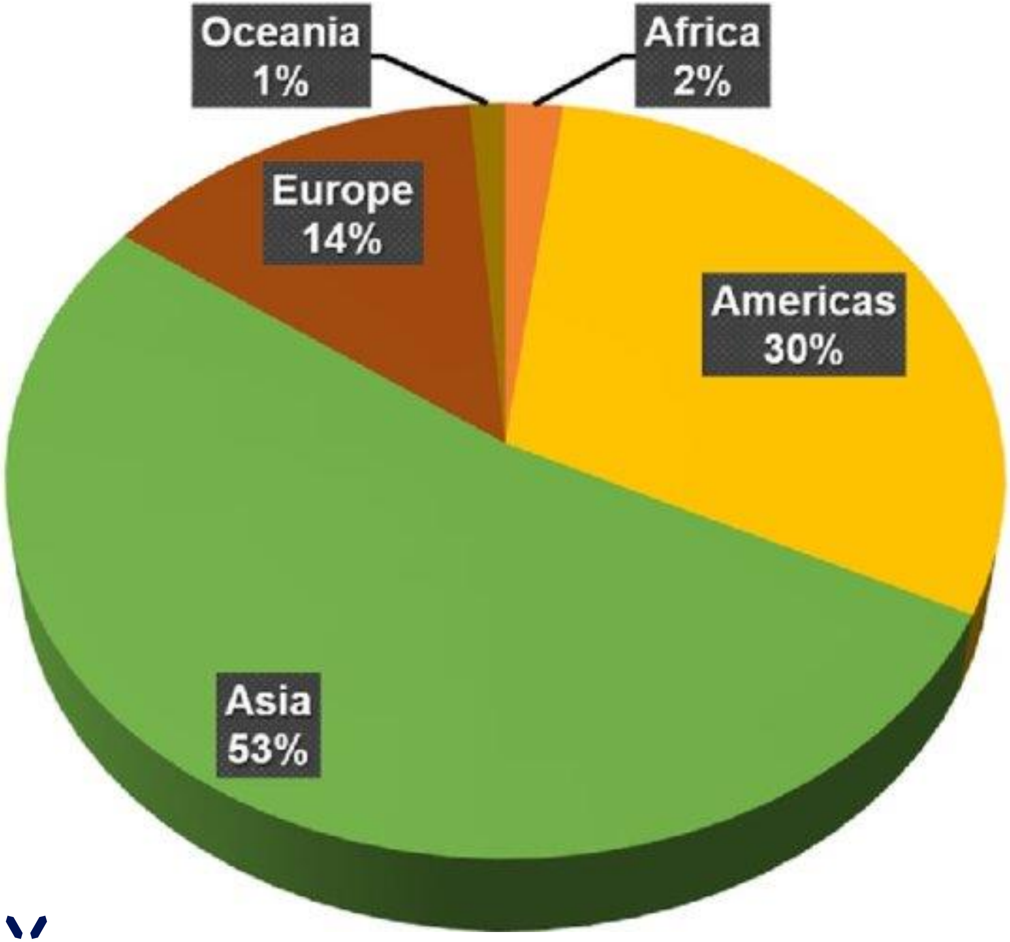
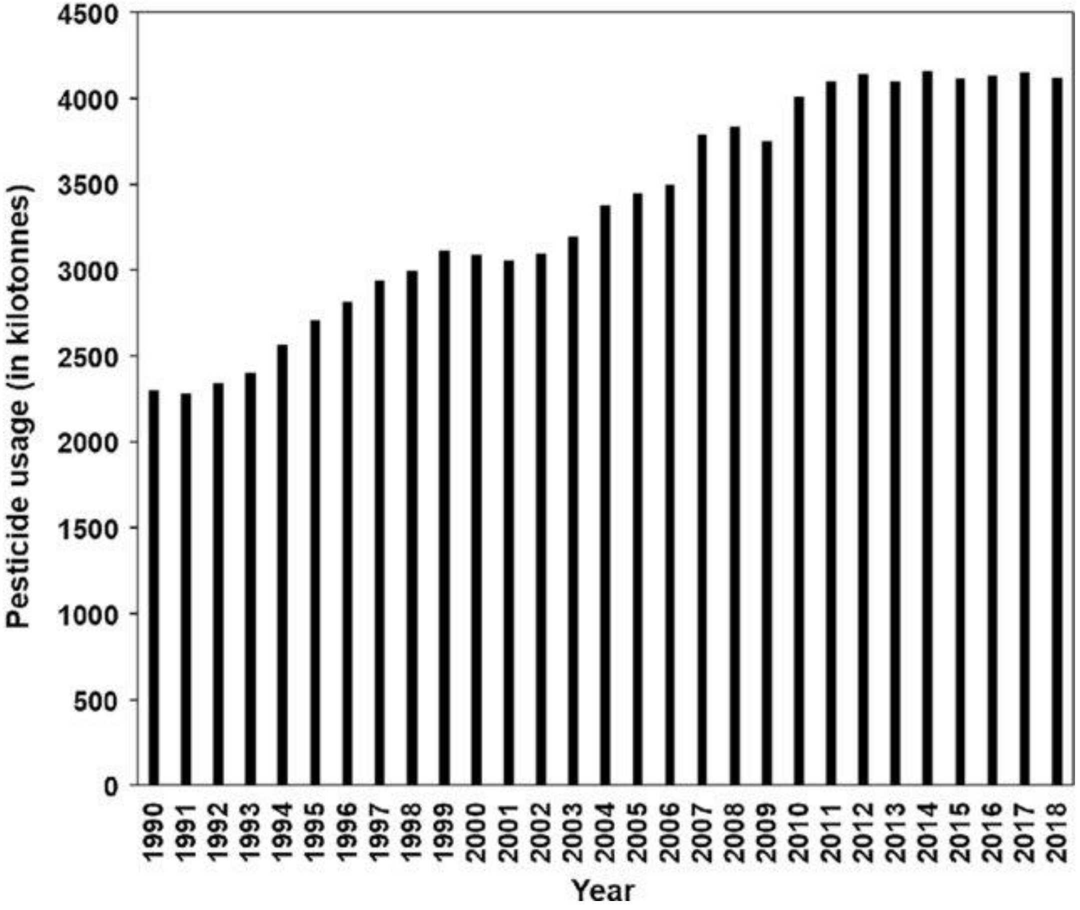
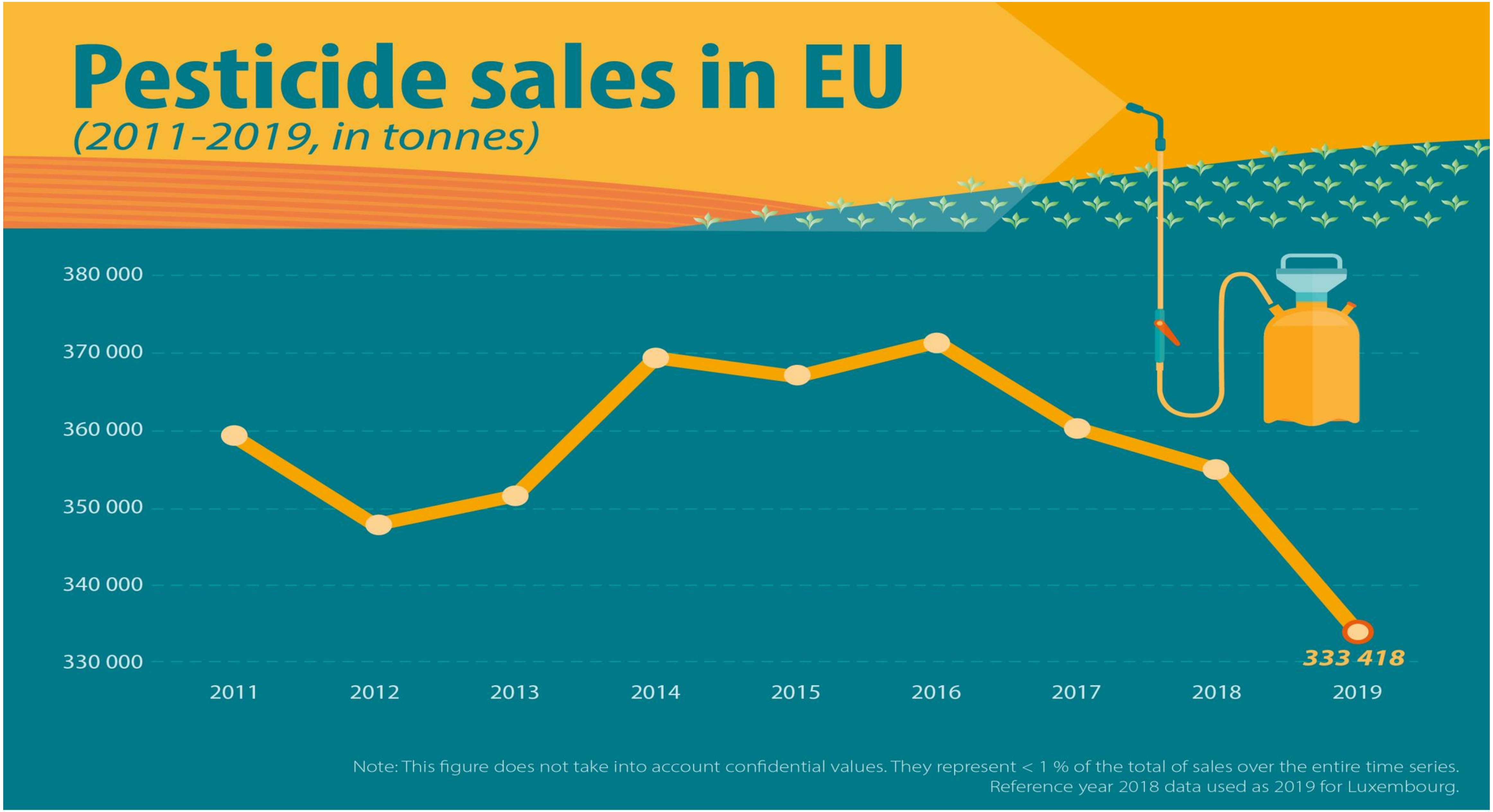
Global pesticide usage over the years, based on data from FAO







ec.europa.eu/eurostat

IPDM- Integrated Pest and Disease Management

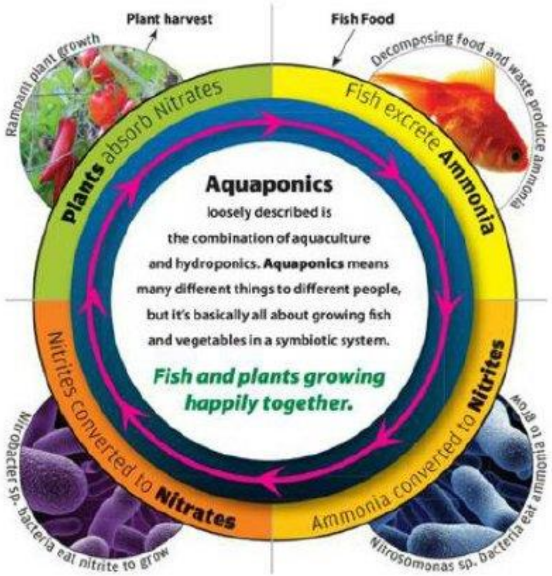
- Consumers demand healthy, bio or organic crops
- Healthy food, a new comprehensive and sustainable approach to control method→ **IPDM and IPM**
- Ecologically based control strategy
- Relies mostly natural mortality factors such as natural enemies o pests, wheather etc.,
- And replaces excessive use of pesticides to other control methods

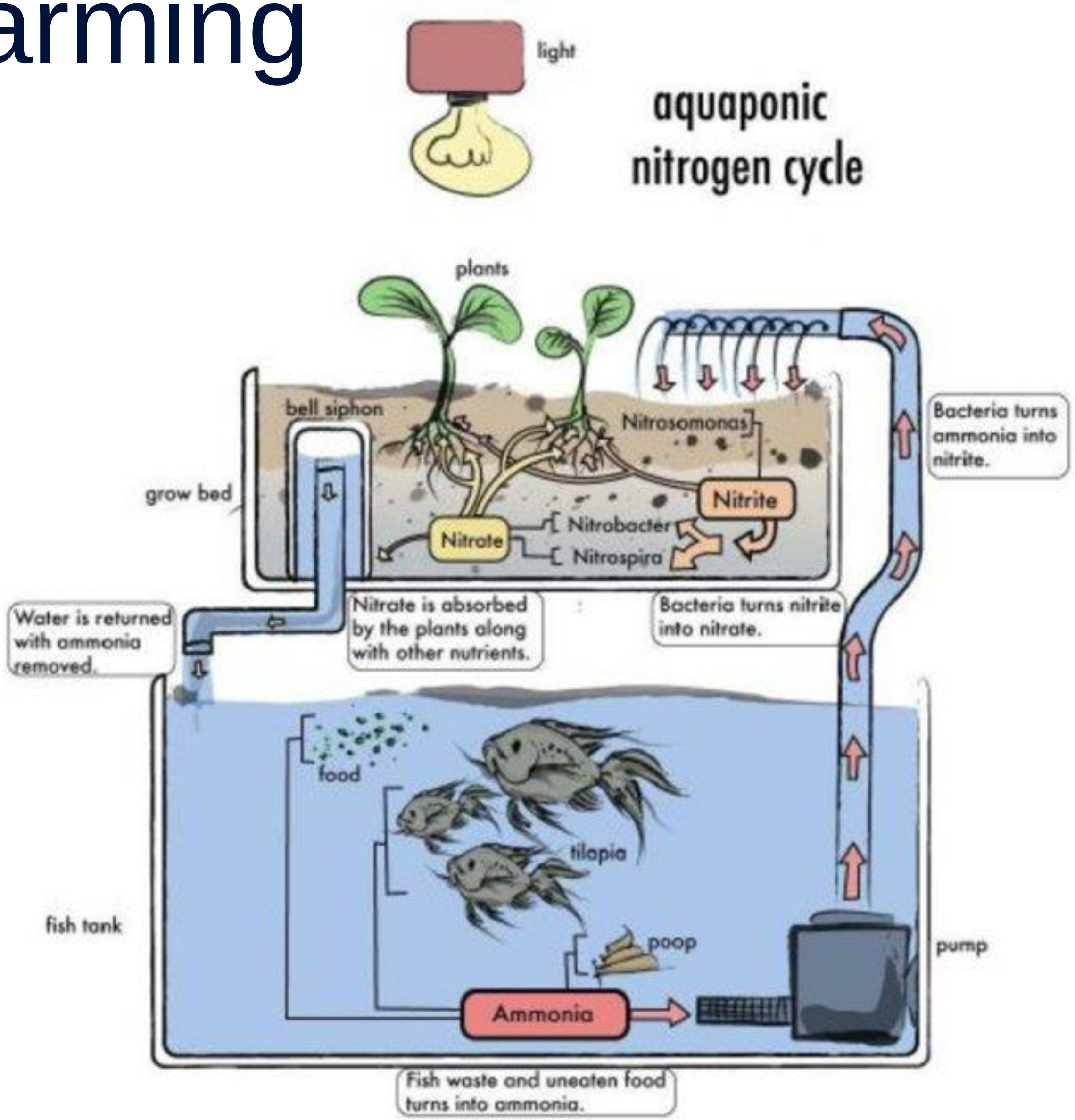
It means that farmers will not anymore use Pesticides?

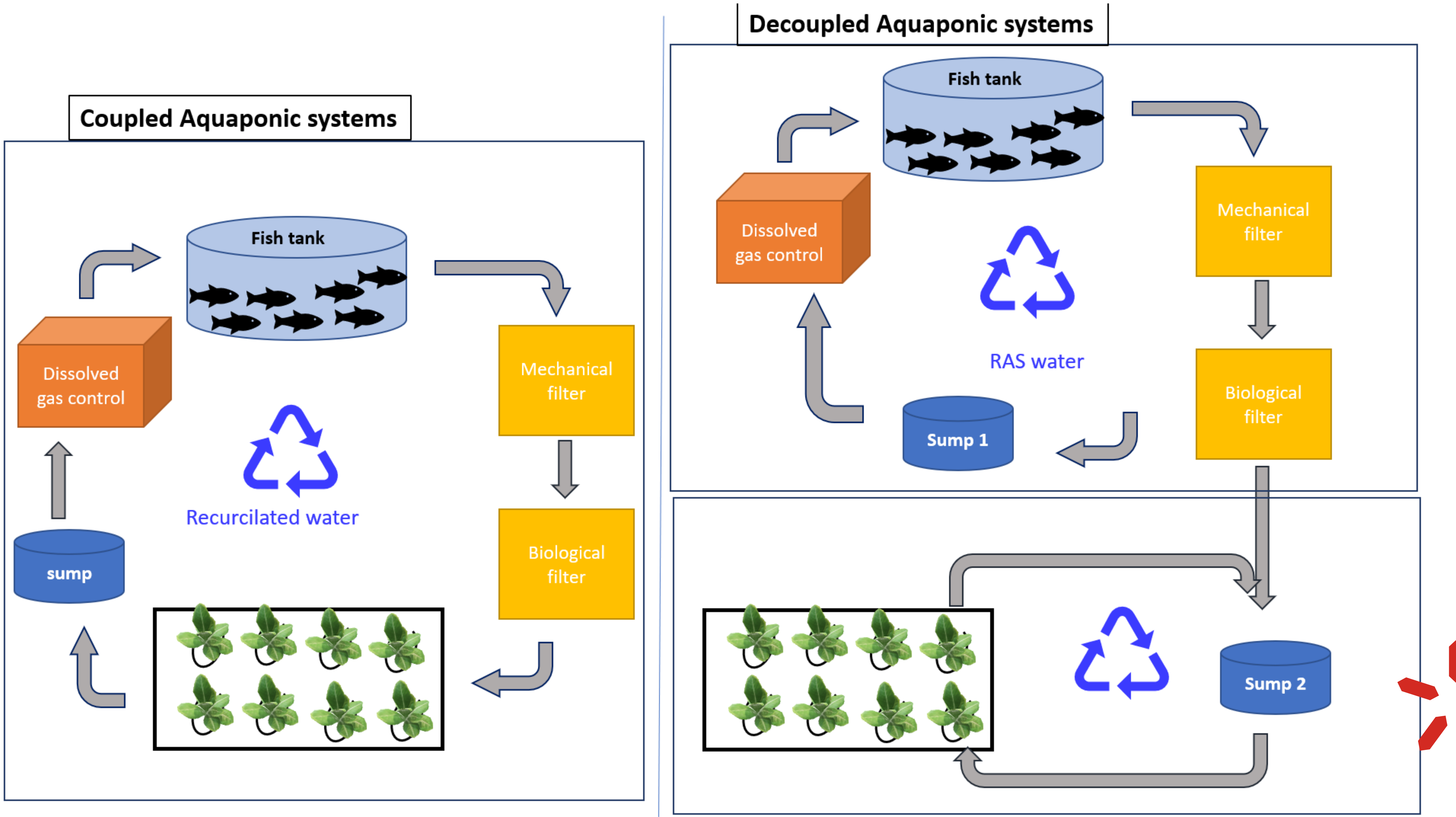
- Mostly the fastest and easiest way to find: chemical control
- IPDM has also pesticides its control list,
- But only after systematic monitoring of pest populations and spreading of disease
- No replace combatting method, all arrows are pointing up this combating method

IPDM in Soilless Farming

- Fishes
- beneficial bacteria as biological filter







Coupled Aquaponic systems
Fish tank
Dissolved gas control
Mechanical filter
Recurcilated water
Biological filter
sump
Decoupled Aquaponic systems
Fish tank
Dissolved gas control
Mechanical filter
RAS water
Biological filter
Sump 1
Sump 2

Most Common Diseases in Soilless Systems

Disease	Causal agent	microbial type
Grey mold	*Botrytis cinnerea*	fungus
Powdery mildew	*Golvinomyces cichracearunm*	fungus
Fusarium wilt	*Fusarium oxysporum f.sp. lactuca (FOL)*	fungus
Lettuce drop	*Sclerotinia spp*	fungus
Phytium root rot	*Phytium spp.*	oomycete
Phytophthora root rot	*Phytophthora spp.*	oomycete
Downy mildew	*Bremia lactucae*	oomycete
Bacterial wilt	Ralstonia solanacearum	bacteria

FUNGAL PLANT DISEASES

Gray mold (*Boytris cineria*)

Fusarium wilt (*Fusarium oxysporum f.sp. lactuca (FOL)*)

Powdery mildew

Downy mildew (*Bremia lactucae*)

PLANT DISEASES

Damping off (*Phytium spp.*)

Bacterial diseases

Bacterial leaf spot (*Xanthomonas campestris pv. vitians*)

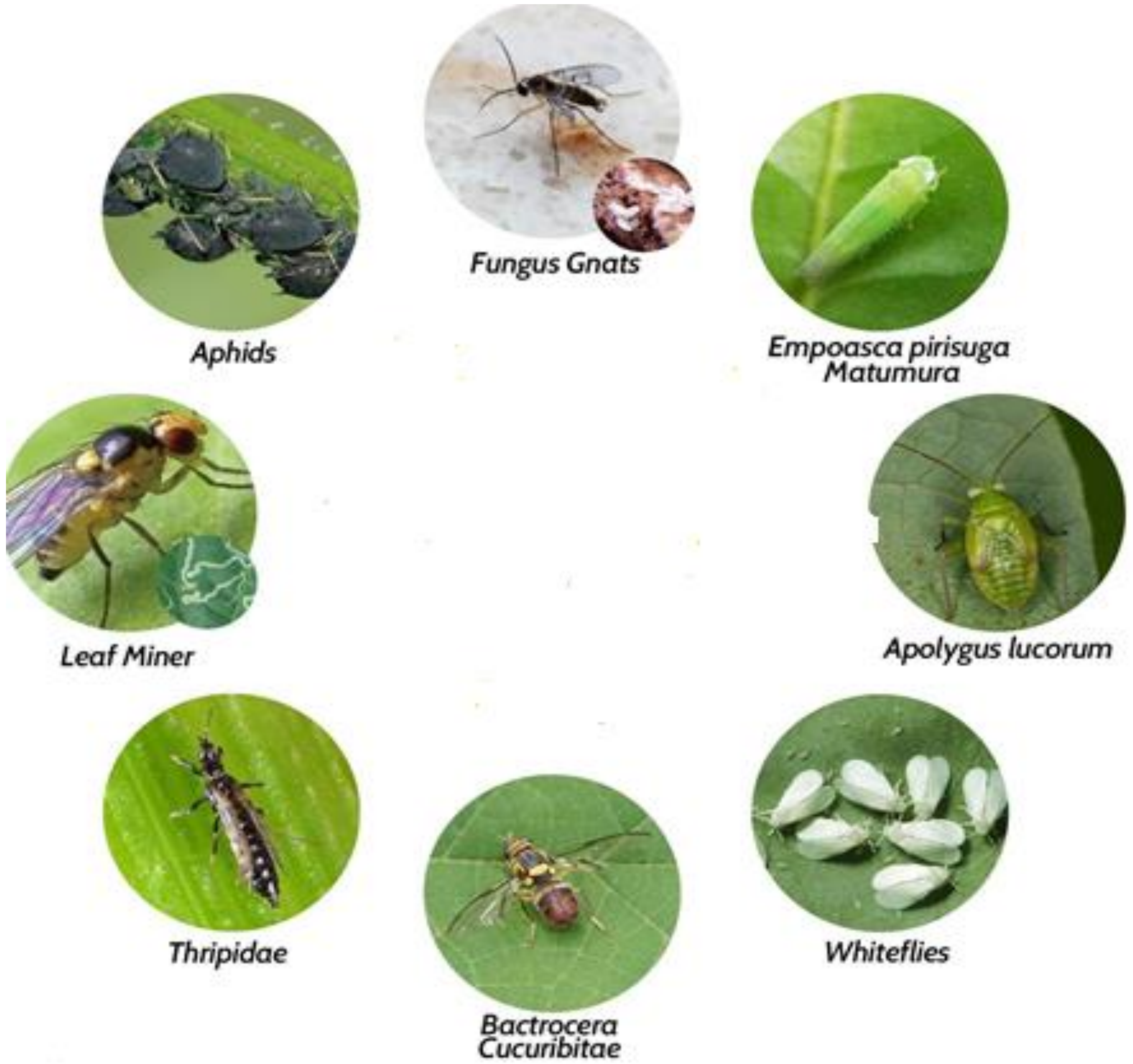
Soft rot (*Pectobacterium carotovorum subsp. carotovorum*)

Causal organisms viruses

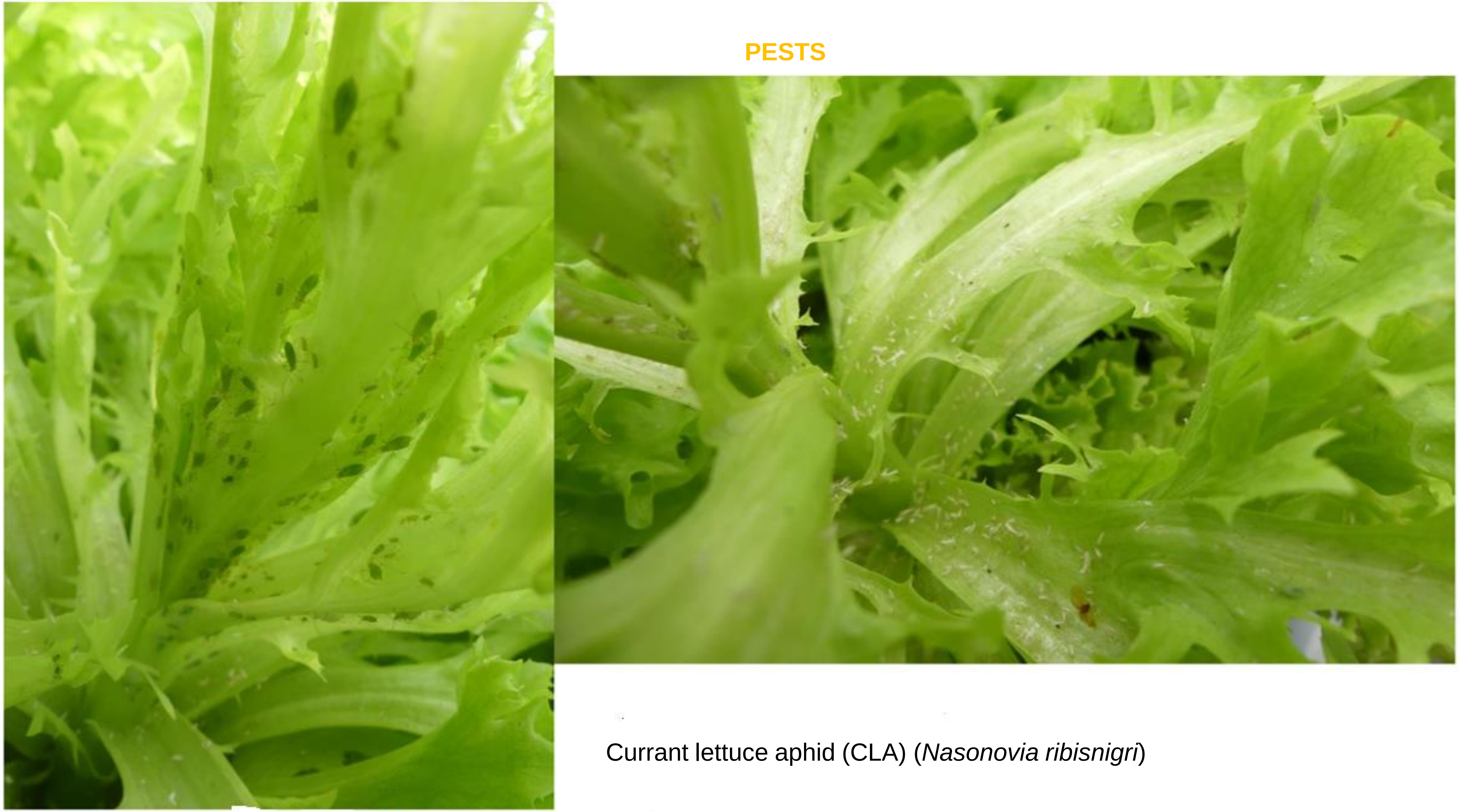
Lettuce infected with the big vein virus

Tomato spotted wilt virus (TSWV) on lettuce

Pests


Fungus Gnats
Aphids
Empoasca pirisuga Matumura
Leaf Miner
Apolygus lucorum
Thripidae
Whiteflies
Bactrocera Cucuribitae

PESTS



Currant lettuce aphid (CLA) (*Nasonovia ribisnigri*)

Control Steps

1. preventation
2. Identification
3. Monitoring of pest/disease activity
4. Determining and selecting control method(s)
5. Assessment of the method

IPDM Steps

IPM Steps	Pest and disease management procedure	HP	CAP	DAP (without water reuse)
Prevention	• Sanitation of work equipment and soilless systems,	√	X	√
• pest and disease detection and identification, • monitoring of pest or disease, reviewing and selection of control methods	- No possible effect	√	√	√
Cultural control	selection of disease resistant crop variety, environmental manipulation such us lowering humidity, planting certified seeds, disinfecting tools, using pathogen- free water	√	√	√
Physical control	jet streaming with water (for pests), Ultraviolet irradiation (for water-borne pathogens), Blue-light emitting diodes, heating	√	√	√
mechanical control	picking/blasting,	√	√	√
biotechnical control	sticky cards, phenomena traps	√	√	√
biological control	• predators, • parasitoids, • microbial inoculant, • entomopathogenic fungi	• √ • √ • √ • √	• √ • √ • X • √	• √ • √ • √ • √
chemical control	insecticides, fungicides pesticides can lead to destruction of beneficial bacteria, alteration of biofilter efficiency, residual effect on fishes in aquaponic systems	√	X	√
Assesment	- No possible effect	√	√	√

HP: hydroponic
CP: Coupled aquaponics
DAP:Decoupled aquaponics

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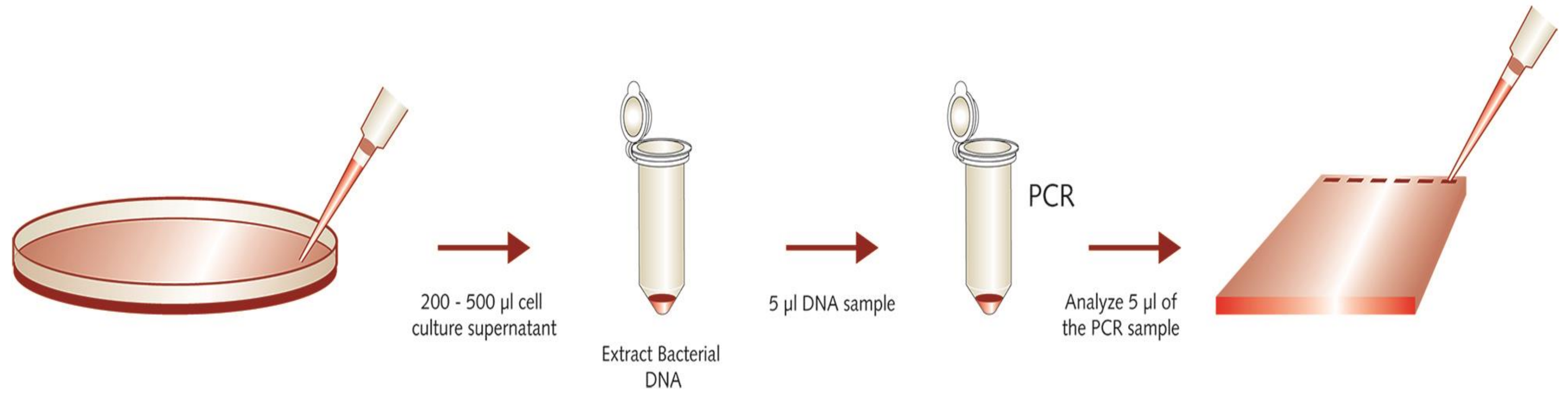
DETECTION, TRESHHOLD AND MONITORING

Detection

- Macroscopic and miscroscopic observation
- Isolation of pathogen (in agar)
- Use of serological methods
- Molecular methods (PCR test etc.)

Rapid pest detection, identification and subsequent monitoring can simply keep the pest popu lation below the economic threshold (action threshold).



CONTROL METHODS

Cultural measurements

- selection of disease resistant crop variety,
- environmental manipulation such us lowering humidity,
- planting certified seeds,
- disinfecting tools,
- using pathogen- free water

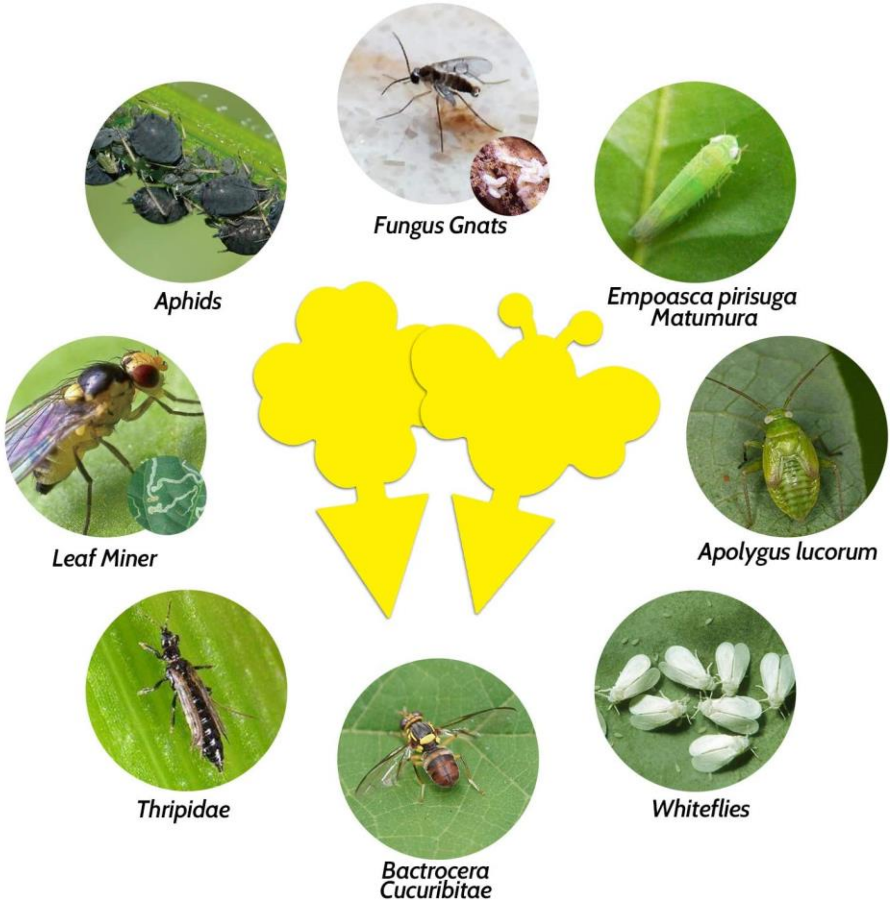
Physical -mechanical control

- jet streaming with water (for pests), Ultraviolet irradiation (for water-borne pathogens), Blue-light emitting diodes, heating
- picking/blasting

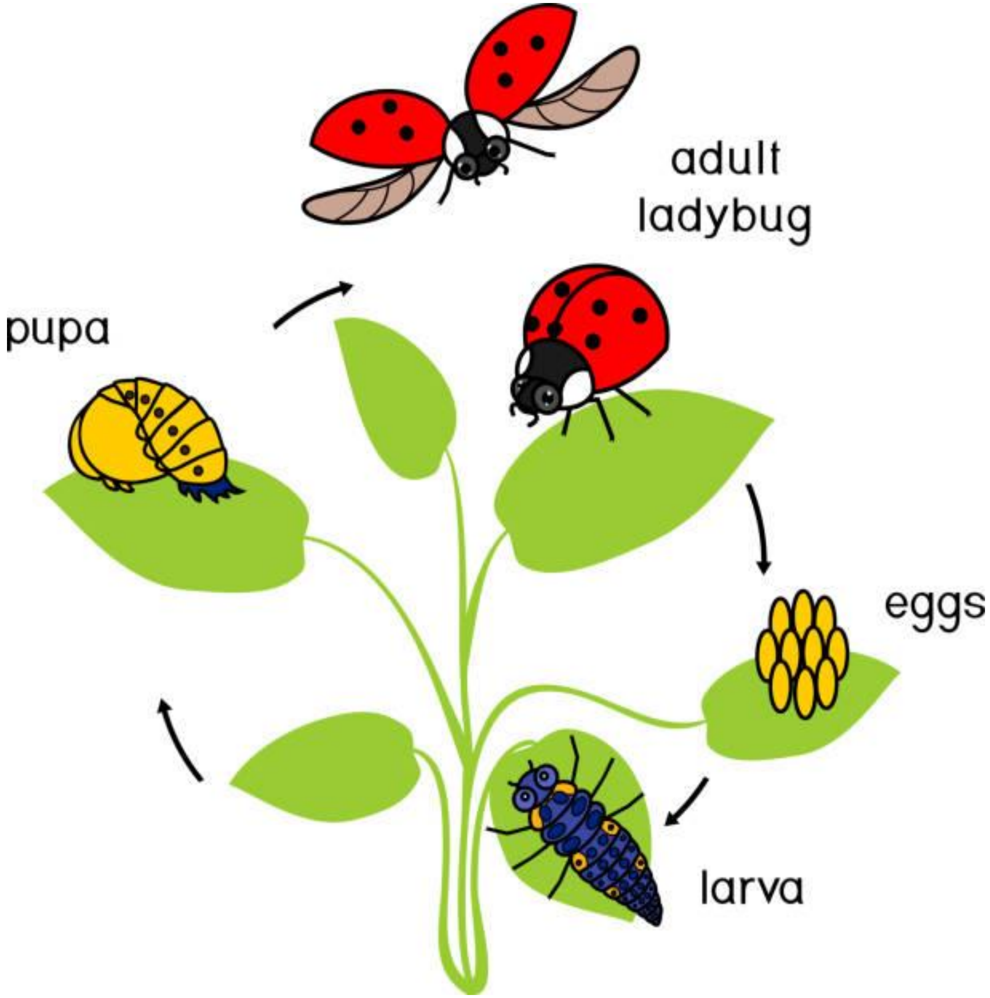
Biotechnical Control

Pheromone traps

Sticky cards
-observation
-combatting



How feed ladybird beetles



SEVERAL LADYBIRD BEETLE SPECIES

- Arthropods acount for 80% of animal kingdom
- About 5000 different species of ladybuds
- A lady bug (larvae or adult) can daily eat 50 aphids

Biological Control

Scymnus levaillanti (Mulsant.) (Coccinell
the most common species of ladybird be
ion

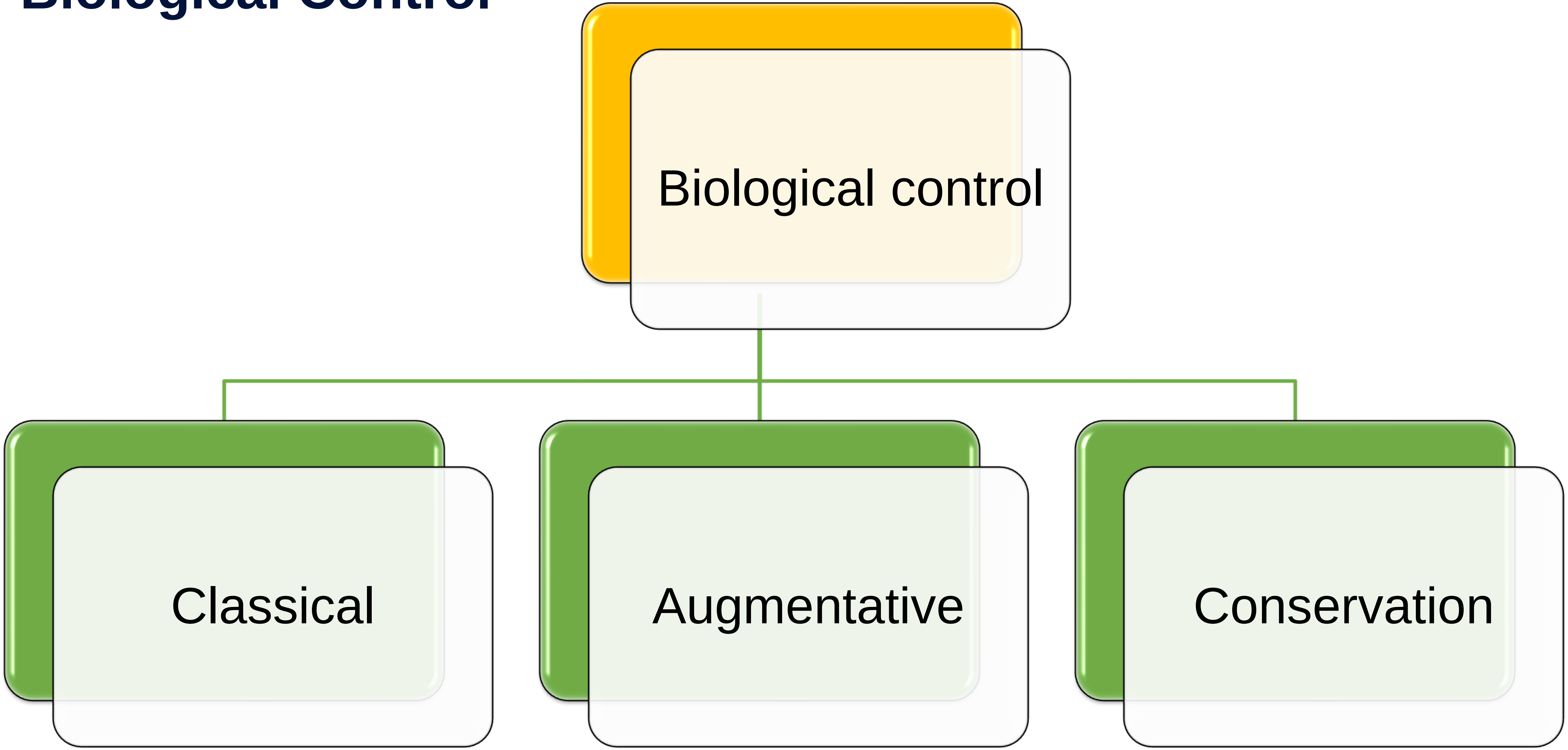
CONTROL METHODS

Biological Control

Three types of Natural Enemies

- Predators: eat many prey in a lifetime, feeding both as young and as adults.
- Parasitoids: specialized insects that develop as a young in one host, eventually killing it.
- Pathogens: nematodes, viruses, bacteria, fungi, protozoans.

Biological Control



Biological Control

- The place of biological control in world agriculture:
- In 2050, it is estimated that biological control will have a rate of 35-40% in plant protection.

- 95% of potential pests (species) are under natural (biological) control without human intervention; all other methods are used against the remaining 5% (5000 species) harmful species.

- The benefit of natural (Biological) control to ecosystems is estimated at at least $400 billion per year

Commercial natural pesticides

Natural pesticides	Pathogens/ pests	Effective dose for pest (mg L^{-1} or indicated otherwise)	LC_{50} for fish (mg L^{-1} or indicated otherwise)	Half-life in water (days)
Clove oil	*Rhizoctonia* spp.	100%	14.1	3.27
	Pseudaletia unipuncta	0.04–0.69%		
Thyme oil	*Botrytis* spp,	1	6.6	15
	Aspergillus flavus	350–500		
Garlic	*Phytophthora infestans*	55–110	6.19%	15
	Fusarium oxysporum	50%		
Caraway	*Penicillium* spp.	2	14	
Rosemary	Spider mite	7.5–10%	3.4	37.5
Cinnamon	*Penicillium* spp.	3	–	15
Lecithins	*Sphaerotheca fuliginea*	0.2%		
Citronella	*Hyadaphis foeniculi*	0.53–0.56	17.3	30
Oregano	*Botrytis cinerea*	1	5	–
	Penicillium spp.	2–3		
Lavender	*Botrytis cinerea*	25.6	99.7	–
Neem	Mustard aphids	5%	4	0.03–4
	Rhizoctonia spp.	100		
Peppermint	*A. flavus* strains	0.05	38 (4 hours)	9
Citrus	*Penicillium* spp.	3	0.7	0.167
	Aspergillus flavus	1.6%		

Herbs

Natural Pesticides and Microbial Inoculant

Neem Oil

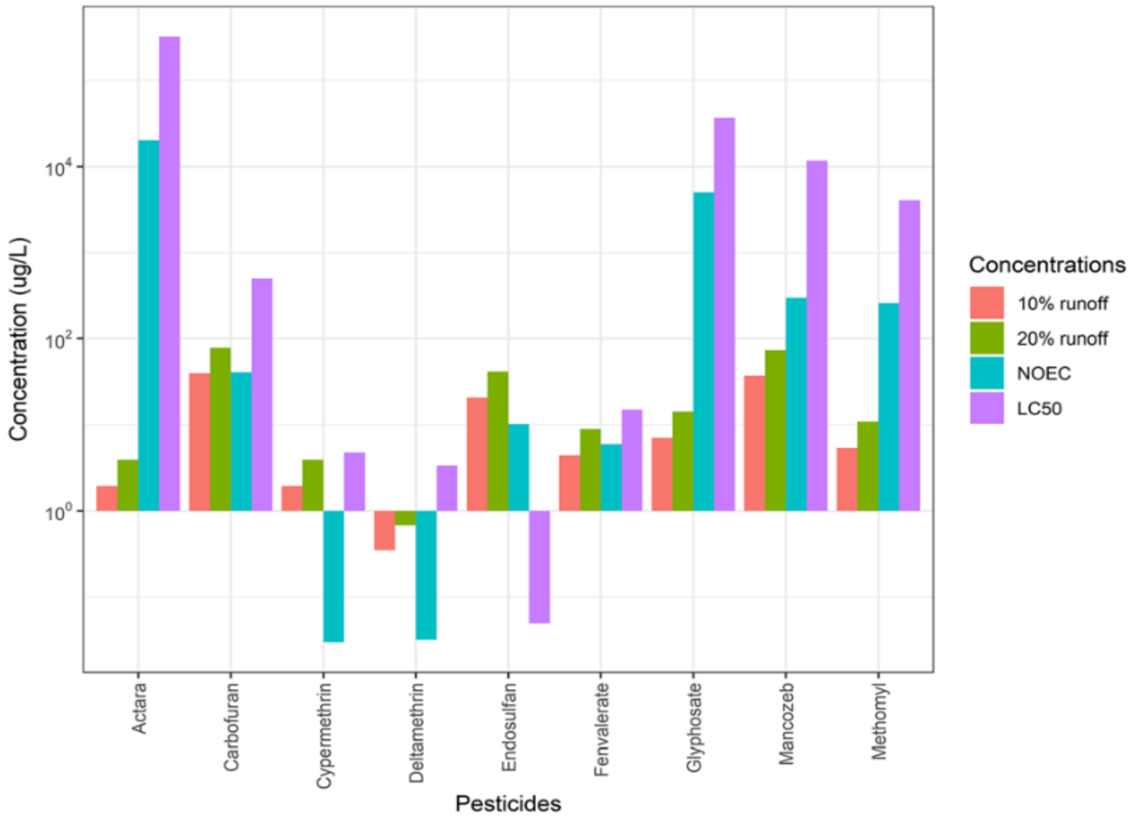
Severely stunted lettuce plants affected by Pythium wilt disease. A healthy plant is on the left

Y tambe

microscopic image of the bacterial spore formation of *Bacillus subtilis*(ATCC 6633) Spore staining, magnification:1,000. (green) spores, (red) vegetatives.

Chemical Control in Aquaponics

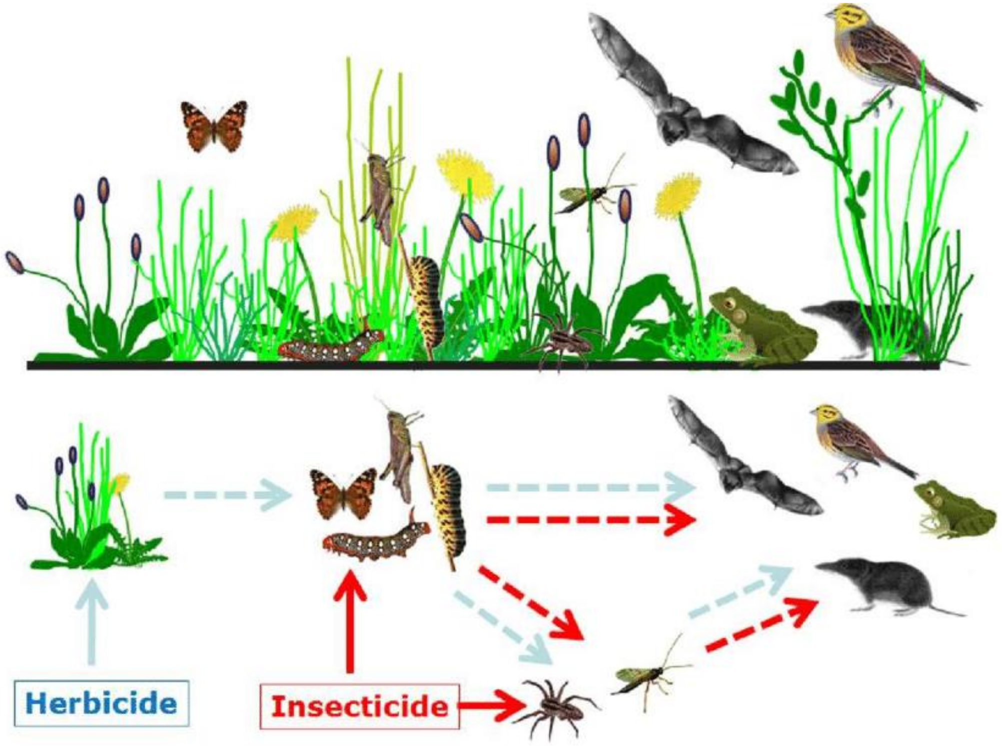
LC50 on Nile Tilapia (*Oreochromis niloticus*)



Comparing no observe effect concentrations ((fish) and LC50 with simulated 10% and 20% runoff of application doses obtained from established application doses of pesticides (n = 30). At 10% runoff con- centrations, deltamethrin, cypermethrin and endosulfan values are greater than their corresponding NOEC values. Endosulfan is the most toxic to fish with concentration (20.7 lgL1) greater than corresponding NOEC and LC50 concentrations (Folorunsa et. al, 2021).

Last Resort: Chemical Control

- not using broad-spectrum detrimental effect on non- target organisms, selected insecticides
- PHI low
- Using pesticides from different groups to prevent development of resistance
- Endosulfan showing the highest toxicity in aquaponics by following cypermethrin, deltamethrin and carbofuran



Above: Presence of non-target organisms. Below: Direct (straight arrows) and indirect effects (dashed arrows) of pesticides, blue: herbicide, red: pesticide. (Brühl, 2017)

Synthesis: Combined Control Strategies

- P. Persimilis has been introduced into greenhouse
- Agri-Mek 0.15 EC (Abamectin 2 %) without harming the predators
- Sticky cards for identifty and count

IMPLEMENTATIONS

Sandponic, media-bed and NFT hydroponic systems

Biological Control

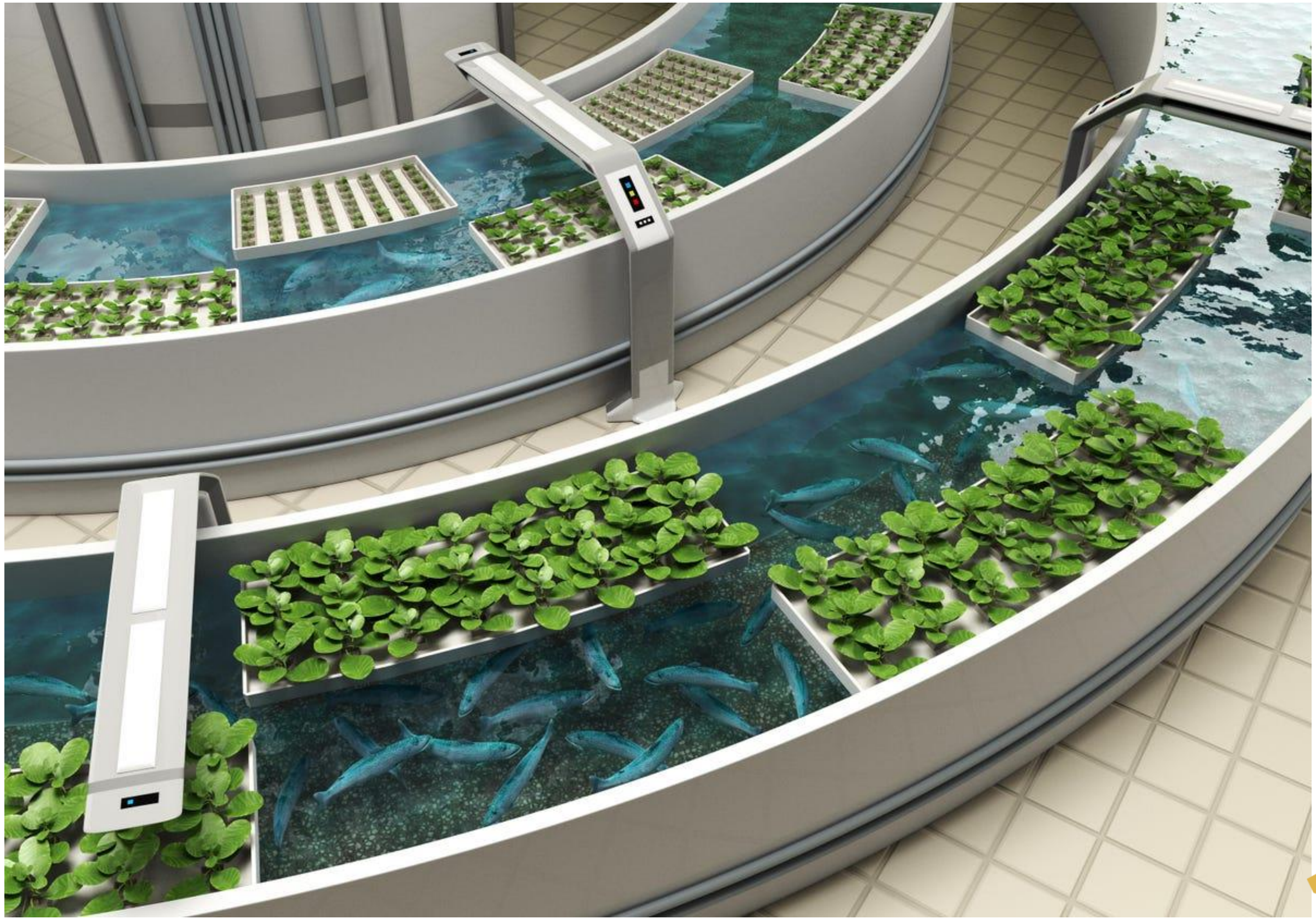
Thrips and their damages

ORIUS predator is spread on sawdust

Predator, natural enemy of thrips
Orius albidipennis

Summary

- Current knowledge suggests that, although apparently opposite, organic and high-tech soilless cultivation have several common or converging points in view of a sustainable use of resources on the planet.
- As a consequence, new policies should be oriented toward a reduction of environmental “pressure” by introducing a process certification of low environmental impact, which, together with an adequate product certification, related not only to the environmental aspect but also to product quality, can reduce the opposition of the two cultivation systems.
- All pesticides influence phosphorus and nitrogen avail ability in water. Natural pesticides show no acute toxicity to fish at runoff concentrations, but they should be avoided in coupled systems
- In biological control, except microbial inoculants, natural enemies of pests (predators and parasites) are mostly safe for any aquaponic design.
- To use of synthetic pesticides can be directly deleterious. However, there are available alternatives to completely replace the use of synthetic pesticides.



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Thank you for your attention

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AWESOME

WATER-ECOSYSTEM-FOOD

PRIMA

PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

This project is part of the PRIMA Programme supported by the European Union. having received funding from it under grant agreement No 1942

ANNEX II

PARTICIPATORY WEFE NEXUS NARRATIVES WORKSHOP

The narratives constructed as part of that activity have been developed in the underlying context of climate change and the need to reduce water demand, addressed in AWESOME, with the use of soilless agriculture techniques and desalination as these solutions are explored in WP4 and reported in D4.3 Efficient WEF Planning Portfolios. Particularly it is based on the assessment of portfolios that explore multi-dimensional synergies and trade-offs across a series of evaluation indicators and performed for current and future climatic and socio-economic scenarios.

Future narratives are qualitative storylines that capture a future vision for the case study area and portray a visionary image of the site in a future where the various sectors work together to enhance WEFE synergies. In that workshop, the stakeholders explored the state of the key drivers in the context of future trends and built storylines around them. The activities that took place during the workshop attempted to inspire the participants and mobilize them to develop shared narratives along with the project's researchers.

Indicators refer to a set of quantitative measures/ descriptors that outline the parameter setting against which AWESOME's modellers have made their projections for the Nile River Basin. These are environmental and socio-economic indicators such as population growth, climate change etc which drive the system under research. They quantify the main themes of the future narrative and reflect identified drivers. In the context of AWESOME, the indicators' trends projected by the project's scientists were correlated with the perceived by the stakeholders' trends.

Here follow the selected indicators along with their explanation:

DRIVERS	INDICATORS	MODEL TREND
Population growth	Total fertility rate	Increase
	Life expectancy	Increase
	Migration	Increase
Climate change impacts	Precipitation	Decrease
	Temperature	Increase
	Streamflow	Decrease
Irrigated agriculture	Crop water demand variation	Increase
Water supply	Reuse	Varied
	Groundwater	Varied
	Aquaponic	Varied
	Desalination	Varied
Ecosystem Services	Crop production	Increase
	Fruits &vegetables	Increase
	Livestock production	Increase
Transboundary cooperation	Transboundary / regional policies	-
	Transboundary networks	-
	Internat.strategic agreements	-

Population growth: Demographic projections are important as they provide data regarding the population evolution and key economic indicators for the countries of interest and the whole Mediterranean region, under the Shared Socio-Economic Pathways (SSP) scenarios. Indicators affecting that driver are:

a) Total fertility rate: the average number of children a woman would bear if she survived through the end of the reproductive age span and is one of the key components in population projections
b) Life expectancy: it is related to the mortality rates
c) Migration: plays an important role in the evolution equation for the total population

Climate change impacts: as the main challenge tackled by AWESOME project through the development of soilless agriculture technologies. The downscaled climate projections over the Nile River Basin and Egypt rely on the IPCC's fifth assessment report exploring different radiative forcings. The climatic analyses used the following indicators:

a) Precipitation: the water arriving in the case study area as one of the main components of its water cycle
b) Temperature: the degree or intensity of heat as affected by the

c) Streamflow: it was assessed based on hydrologic model and climatic scenarios in order to generate the streamflow corresponding to the projected precipitation and temperature conditions for all the modeled tributaries of the Nile River, i.e., Blue Nile, White Nile, Dinder, Rahad, Tekeze, and Atbara

Irrigated agriculture: current and future crops' water needs are important aspects of the water supply and demand models. Crop water demands were estimated under the climate scenario RCP4.5. Current crop distribution was considered as well as different options of crop reallocation, aiming to enhance agricultural production and preserve the consumption of irrigation water. Indicators are:

a) Crop water demand variation under current crop distribution &CC
b) Crop water demand under reallocation scenarios/ Nile RB
c) Total cropland under reallocation scenario/Nile RB

Water supply and demand: as the two main components of the strategic model for the Nile River Basin developed in the framework of WP4. One water supply model supports the analysis of the operating policies of the main dams along the Nile River, along with the water abstraction for the irrigation areas in Sudan and the water supply downstream of the High Aswan Dam. Another model on water demand investigates combinations of water demand interventions, namely reuse, groundwater, aquaponics/hydroponics, and desalination, to reduce the water demand downstream of the High Aswan Dam. This is important for the portfolios as there are analyzed the impacts of water demand reduction portfolios on the system downstream of HAD. The selected portfolios define a combination of drainage reuse, groundwater extraction, aquaponics, and desalination plants. Indicators are:

a) Reuse and groundwater: water demand reductions can be obtained at lower costs by increasing water reuse and groundwater pumping (however with higher environmental risks)
b) Aquaponics and desalination: those two are based on the introduction of advanced water demand technologies that are supposed to reduce water demands (however they require high initial investments and desalination is energy intensive). Particularly for aquaponics, has been chosen the lettuce as the reference crop and it is modeled by assuming a conversion of part of the agricultural production of lettuce from traditional farming to hydroponics.

Ecosystem services: the many and varied benefits to humans provided by the natural environment and case study area’s ecosystems which are affected by the current WEFE situation. Indicators are:

a) Crop production: the production from irrigated agriculture particularly cereals, crops, sugar, and molasses (that have the highest production) and it is a provisioning service
b) Fruits and vegetables: Balanities aegyptica (Lalop), Tamarindus indica fruits (Koat) and wild vegetables which are provisioning services
c) Livestock production: Essential for pastoralists and farming families using wetlands as watering points and pasture. It depends on the variability of livestock meat and milk as well as feed water productivity.

Transboundary cooperation: It is related to SDG 6.5.2 and plays a crucial role in supporting wider regional integration, peace, and sustainable development, as well as in tackling regional security challenges and supporting climate change adaptation. It is one of the evaluation indicators used in the meso level Decision Analytic Framework (DAF), where the percentage of transboundary basin area within a country that has an arrangement for water cooperation is a bilateral or multilateral treaty, convention, agreement, or other formal arrangement between riparian countries that provides a framework for cooperation.

The last descriptor is not something that was projected in AWESOME but was of the team's interest to introduce it into the discussion with the stakeholders and receive trends on that.

STAKEHOLDERS TRENDS

With the use of a Mentimeter survey that run during the workshop the team received the following results from the stakeholders based on their views:

DRIVERS	INDICATORS	MODEL TREND	STAKEHOLDERS TREND
Population growth	Total fertility rate	Increase	Increase
	Life expectancy	Increase	Increase
	Migration	Increase	Increase
Climate change impacts	Precipitation	Decrease	Decrease
	Temperature	Increase	Increase
	Streamflow	Decrease	Varied
Irrigated agriculture	Crop water demand variation	Increase	Increase
Water supply	Reuse	Varied	Increase
	Groundwater	Varied	Increase
	Aquaponic	Varied	Increase
	Desalination	Varied	Increase
Ecosystem Services	Crop production	Increase	Increase
	Fruits &vegetables	Increase	Increase
	Livestock production	Increase	Varied
Transboundary cooperation	Transboundary / regional policies	-	Decrease
	Transboundary networks	-	Increase
	Internat.strategic agreements	-	Varied

- Total fertility rate: increase 38%, decrease 25%, varied 13%, no change 13%, don't know 13%
  Life expectancy: increase 88%, don't know 13%
  Migration: increase 63%, decrease 13%, varied 13%, don't know 13%
- Precipitation: increase 13%, decrease 38%, varied 25%, no change 13%, don't know 13%
  Temperature: increase 71%, decrease 0%, varied 29%, 0%, 0%
  Streamflow: increase 29%, decrease 29%, varied 29%, no change 14%, 0%

- Crop water demand variation under current crop distribution: increase 43%, decrease 29%, varied 29%, 0%, 0%
  Water supply – reuse: increase 100%
  Water supply – groundwater: increase 43%, decrease 43%, varied 14%
  Water supply – aquaponics: increase 86%, decrease 0%, varied 14%, 0%, 0%
  Water supply – desalination: increase 71%, decrease 0%, varied 14%, no change 14%, don't know 0%
- Ecosystem Services – crop production: increase 86%, decrease 14%, 0%, 0%, 0%
  Ecosystem Services – fruits &vegetables: increase 86%, decrease 14%, 0%, 0%, 0%
  Ecosystem Services – livestock production: increase 38%, decrease 13%, varied 38%, no change 0%, don't know 13%