Improving MEDiterranean irrigation and Water supply for smallholder farmers by providing Efficient, low-cost and nature-based Technologies and practices

(MED-WET)

A CONCEPT NOTE

on A Pilot Case:

Productive constructed Wetland technology for Wastewater Reuse in Wahat El-Baharia, Egypt

Pilot Lead: Heliopolis University for Sustainable Development, Egypt

Project Team:

Staff of the Civil Engineering Department, Faculty of Engineering, Heliopolis University, Cairo, Egypt

February 2022

The PRIMA programme is supported and funded under Horizon 2020, the Framework European Union's Programme for Research and Innovation

A CONCEPT NOTE

1. Introduction

The majority of the Mediterranean countries have been facing threatening water scarcity. The obvious climate changes are additionally stressing the limited water reserves, particularly the agriculture sector. Population growth, changing food consumption patterns and desertification are expected to intensify the stresses. This calls for more efficient and sustainable irrigation technologies that are widely applicable for smallholder farmers. They must be low-cost, lean solutions that optimize natural resource use and income even at small scales. MED-WET provides such solutions to enhance irrigation efficiency as well as to increase freshwater availability by tapping into non-conventional water sources. Our selected solutions are low-tech, low-energy, easy-to-operate solutions using cheap, locally available and natural materials geared towards financial feasibility.

Arid countries, such as Egypt (among other middle eastern countries), are facing a water scarcity crisis, which requires optimizing the use of all available water resources (conventional and non-conventional types). Due to that, reuse of drainage water is becoming an increasingly fairly useful water resource in Wahat El-Baharia as well as in most of the old lands in the three Nile Delta Regions. In the Nile Delta, however, large portions of water in the drainage network cannot be used as they contain high contaminant loads.

One of the objectives of the MED-WET project is to develop productive constructed wetlands to transform communal or farming wastewater (wetland stage 1) into reclaimed irrigation water, which flows into the subsequent productive wetland units with special species crops (wetland stage 2). This enables farmers to directly utilize safe-for-reuse and nutrient-rich effluent for crop farming. Crop selection and placement is targeted to accommodate water and nutrient needs and tolerance.

HUSD as a partner of the MED-WET project will lead the project pilot of the productive wetlands technology and contribute especially to the training components, publishing scientific papers and field visits, through its collaboration with farmer associations and inclusion of student internships and graduate research studies to ensure the project reaches the target groups as well as the beneficiary farmers.

The motives for HUSD to carry out this research project component is the acute water scarcity Egypt is facing combined with the escalating water needs that drive the researchers and scientists to find new non-conventional water resources. Therefore, this research project aims to provide cutting-edge technologies of low-cost and affordable solutions to increase water resources by natural treatment of communal or farming wastewater into reclaimed irrigation water through a constructed wetland system. This resulting water can be safely and sustainably used for irrigating more agricultural crops and trees for more production. Our selected solutions are low-tech, low-energy, easy-to-operate solutions using cheap, locally available and natural materials geared towards financial feasibility.

2. Objectives

The overall objectives of this research project are:

- To construct and operate an experimental engineered wetland (several alternatives) to naturally treat wastewater of **Wahat El-Baharia**, particularly communal sewage and the farms' drainage water.
- Assess feasibility of the optimum alternative of engineered wetland system to improve environmental conditions at the pilot area.
- Assess feasibility of engineered wetland systems to improve water quality so it enables safe reuse of water with fair nutrients contents for the crops, and contributes to the circular economy.
- Transfer and localize cheap and efficient engineering wetland technologies to Egypt.
- Produce policy notes, communication materials, exchange of knowledge within the MED-WET project (work pancakes teams), and
- Conduct outreach programs for the Egyptian graduates and specialists and strengthen the rural stakeholders' participation and awareness in the project area.

3. Activities

The goal that HUSD is aiming to achieve through this research project is ***implementation of a pilot experimental farm for water-producing technology (constructed wetlands) and creation of farmers networks and stakeholder engagement through its relation with the Egyptian Biodynamic Association (EBDA)***. That goal can be achieved through the execution of the following research activities:

1. Conduct a baseline analysis including demographic, technical, social and economic parameters to adapt proposed technologies and business models. The situation analysis will also include a mapping of agricultural water management's best practices applicable to the pilot area.
2. Collect information (literature research of secondary data, key informant interviews with local experts and end-users) in order to identify end-user needs in an interactive co-design process.

3. undertake a limited survey among the rural inhabitants for example to identify the available and suitable local plants in Egypt.
4. Design and implement the productive constructed wetland including plotting the pilot sites (placement of units, pilot fields/control fields), digging works for wetlands and irrigation
5. Measure standard physical and chemical water quality parameters (corresponding to EU Water Reuse Directive) in the effluent, and yield quantity and quality will be evaluated.
6. Conduct operation, testing and analysis/evaluation of various system configurations. During the pilot implementation, the test group users (smallholder farmers) will be regularly invited to 'open days' to provide valuable feedback on the system to prepare a successful eventual rollout to users.
7. Perform an evaluation of design, feasibility, duration, cost, adverse events.
8. Develop a technical guidelines and O&M manuals
9. Conduct capacity building, awareness and communication on the merits of good practices that achieve sustainable development.
10. Avail research opportunities for graduate young engineers and professionals.

In this context, HUSD is planning to answer some specific key research questions, as follows:

- What is the maximum pollutant load (especially nutrients) that a certain type of wetland can tolerate?
- What is the fate of the pollutants retained in the wetlands?
- How to predict long-term performances from short or medium-term data?
- Can some non-hazardous agricultural waste be used as local materials to establish constructed wetlands?
- What are the suitable engineering interventions to enhance the functionality of the wetlands?

The project team shall design a number of key performance indicators (KPIs) as appropriate and shall organize and prepare a series of monthly progress reports showing the progress accomplished, challenges faced, how those challenges were mitigated, KPIs monitoring, and a financial status.

4. Pilot Area Description

The pilot farm is located in ***Wahat El-Baharia, Egypt***. It is an arable land currently under reclamation by Sekem Group in collaboration with Heliopolis University, located in Western Desert (**Figure 1**). Soil classification is dominated by sandy layers. Main cultivation is medicinal and aromatic plants (for essential oil production) and species of trees for CO_2 sequestration purposes and agroforestry systems. The groundwater aquifer is 300 m depth, used sufficiently for irrigation during the last 200 years. That groundwater contains high concentrations of iron content, which significantly challenged the irrigation equipment and infrastructures. No proper wastewater management system exists. The agriculture sector in Wahat El-Baharia is cooperatively providing 3,000 jobs up to 2023. The agriculture workers in Wahat El-Baharia have grown-up and have become a large community, with associated utilities and services. The specific challenges being faced are the very dry climate and low organic matters; partially off grid for electricity; high potential for organic agriculture production and high-quality products good for exports. The existing main source of water is groundwater and the small wastewater produced literally by the inhabitants.

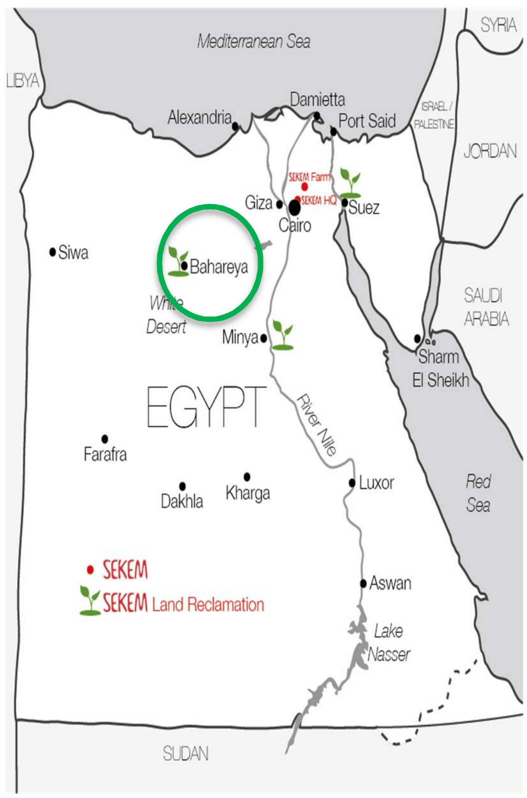

Figure (1): The planned pilot farm located in Wahat El-Baharia, the Western Desert of Egypt

Constructed wetlands are widespread in the rural areas for the treatment of various household, agricultural and industrial wastewaters. **Figure (2)** illustrates the typical constructed engineering wetlands commonly used in Egypt. Yet, that technology has its special settings and components and water losses from evapotranspiration that may limit the benefits of these nature-based solutions in arid regions. The system possibly can include a control weir, a sedimentation zone, floating vegetation barriers and a number of internal berms. Also, vertical-flow constructed wetland used for wastewater treatment shall also be investigated (water and mass budgets) as one of the possible alternatives. HUSD desires that with partnership of MED-WET, it is possible to develop a wetland system that combines several stages of plants strategically placed for de-pollution, high nutrient uptake and economic value creation. This enables safe reuse of water and nutrients and contributes to the circular economy.

Undertaking a preliminary survey with the rural inhabitants in Wahat El-Baharia is important to identify the available and suitable local plant species in Egypt. **Annex (1)** highlights the planned main questions and tasks to be executed during the first field visit to the project site in February 2022. The expected outcome is that the system shall be designed in a way to be able to allocate different plants in parallel configuration in a subsurface horizontal flow. Passive or forced aeration for parts of the wetland needs to be also considered. At the front of the system more classic marshland plants are recommended to be implemented, whereas towards the end, local suitable food crops could be involved. The root zones will be separated by groynes. It will also try to include upcycling materials that are available at the sites. Such research projects need an interdisciplinary approach including bioengineering for designing, structuring and operating the project.

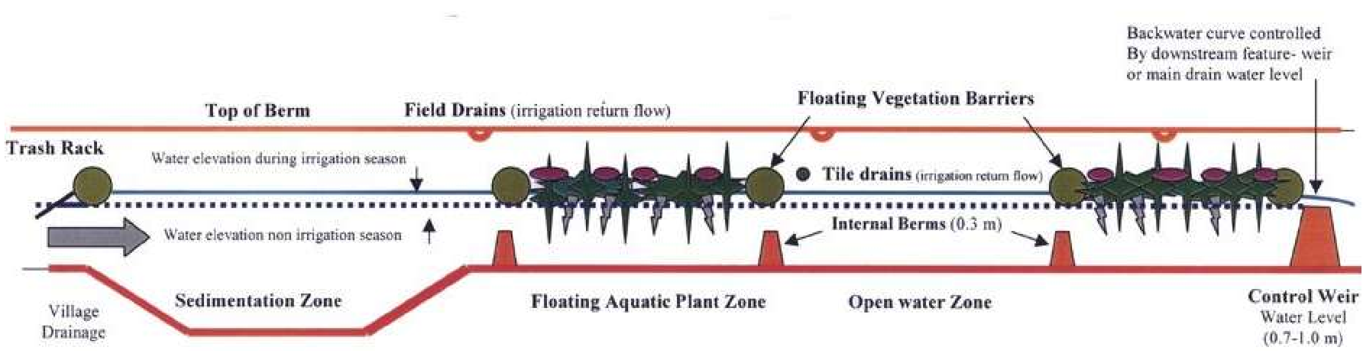

Figure (2): Typical layout of a constructed engineering wetland system

4.1 Advantages of the constructed engineering wetland system

- Treatment efficiency is high, especially biological load treatment.
- Requires relatively low capital investment since no advanced equipment is needed.
- Easy operation and maintenance
- Suitability for hot climate.
- When design criteria of the treatment system are set, replicability in other sites with similar environmental conditions will be possible and feasible.

4.2 Disadvantages of the constructed engineering wetland system

Constructed engineering wetland systems usually occupy considerably large flat lands for conducting the various natural treatment processes. This might not be a challenge since the implementation site is in Wahat El-Baharia, where lands are easily available as well as the land prices are considerably cheap or fair.

5. Expected Outcomes of the Research Project

- Developing and adaptation of a new productive constructed wetland technology that could be suitable for Wahat El-Baharia's physical settings.
- Identifying the sustainable agricultural practices.
- Operating the constructed wetland system, stakeholders' engagement & participation
- Handing over the developed constructed wetland system to the local authorities and end-users (smallholder farmers).
- Developing technical guidelines and O&M manuals for the developed constructed wetland system, including impact evaluation, if any.
- Increasing irrigation water availability
- Enhancing farm profitability and environmental footprint
- Setting a successful model of maximizing the use of all available water resources that can be replicated in other sites with similar conditions.
- Conducting capacity building, awareness and communication on the merits of good practices that achieve sustainable development.
- Publishing technical and scientific papers in the field of constructed wetland technologies and non-conventional water resources in sustainable agriculture.
- Availing research opportunities for graduate young engineers and professionals.
- Producing policy briefs on the values of reusing marginal water through constructed wetland systems in sustainable agriculture thus creating jobs as well as economic returns.

6. Deliverables

The Med-Wet Project is expected to achieve the following deliverables:

- ***Pilot plans and installations, including the productive wetlands details.***
- ***Pilot monitoring plan, describing all points of measurement of the pilots.***
- ***Final pilot monitoring reports, on monitoring and results analysis.***
- ***Best practice catalogue and technical guidelines kits and O&M manuals including adoption of best practices.***
- ***Dissemination reports and policy briefs, and***
- ***Workshops and training manuals for stakeholders.***

7. Preliminary Time Plan

Year One	Year Two	Year Three
Planning	Construction and initial operation	Sharing the results with the MED-WET teams
Site selection	Monitoring of alternative research experiments	Exchange of knowledge and good practices with the WED-WET teams
Procurement of equipment	Results recording	Workshop for results dissemination
Preliminary works	Analysis and discussion of results	Reporting
Monthly reports	Monthly reports	Preparing policy briefs and communications materials
Graduate & undergraduate students' research work	Graduate & undergraduate students' research work	Stakeholders participation, awareness and outreach

8. Preliminary Project Costs Allocation

(approximate estimates out of the gross total of 73,500 €)

Activities	Percentage (%)	Comments
Equipment	25	Components of constructed wetlands prototypes purchased from Egypt market but could partially be imported from foreign markets
Field visits	15	Transportation, accommodation and per diam
Local workers & routine measurements & services	15	Daily works (water quality measurements, groundwater observation, flow, crop growth, …etc) & telecommunication to the project unit at HUSD
Consultancy services	5	Small specialized technical works that the needs expertize does not exist at the project team
Research students works	15	Special experiments/materials/local costs
Production of the communication materials	5	For results dissemination and project publicity to the target groups and stakeholders
Workshops	10	For results dissemination and project publicity
Stakeholders participation	5	At certain stages of the project implementation
Project management & coordination	3	Nominal fees to the project team according to time allocation sheets to the project
Contingency	2	Unforeseen costs arise during the project time

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9. Project Team (Technical Staff) in Egypt

- Prof. Dr. Wael M. Khairy, PI
- Prof. Dr. Sherif Mohamady El-Sayed, Co-PI
- Eng. AyaAllah Yasser Mahmoud, Project Coordinator
- Graduate & undergraduate students of the Civil Engineering Department, Faculty of Engineering, Heliopolis University
- Technical experts from the National Water Research Center of Egypt

10. Project's Stakeholders in Egypt

MedWet Project's stakeholders (Egypt)

#	MED-WET Stakeholders List (Egypt)		
#	Entity type	Entity	Representative Name
1	Govermental institution	National water research center (NWRC)	Prof. AbdelAzim Mohamed Terbak
2	Govermental institution	Drainage research institute (DRI)	Dr. Shereen Yahia Agamy
3	Govermental institution	Agriculture research center (ARC)	Prof. Alaa Mohamed Zoheir Hamed El Bably
4	Private sector (large)	SEKEM For Land Reclemation	Dr. Amr Sabahy
5	Private sector (large)	Egyptian Biodynamic Association (Demeter Egypt)	Mr. Justus Harn
6	NGO/farmers.	Life From water	Mr. Mohannad Hesham
7	NGOlfarmers	Water Will	Eng. Hesham Sadek
8	Owner	SEKEM Development Foundation	Maximilian Abouleish
9	Private sector	NuriWEF	Eng. Ali
10	Private sector	TULIMA	Mr. Seif Salam
11	Private sector	Gebal Egypt	Eng. Hassan Hussany, Eng. Amr Kheriy

Success Indicators

- ✓ **Moving toward fulfilling the MedWet goals and contributing to its target (WP 2: Technology development & adaptation) → clear roadmap with no foreseen obstacles or challenges**
- ✓ **Satisfaction of the recipients → owners, stakeholders and neighbors**
- ✓ **Realizing NWRP2037, Egypt Vision 2030 of Egypt and Sekem Vision Goals 2057 → pollution alleviation**
- ✓ **Upscaling and Outscaling → contribute to filling the gap between water supply and demand in Egypt**

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Annex (I)

Preparatory Survey List in Wahat El-Baharia

Conducted in February 2022 – (in-situ data collection)

Required information about the site/s – Wahat El-Baharia **Question to be answered**
Communities clustering, population and locations
Land uses / land cover (current and future)
Human activities in each cluster
Mapping and land surveying of the sites
Soil classification and soil types
Sources of electricity, telecommunication, roads and transportation conditions
In-situ natural materials to be used in the constructed wetlands
Types of plants, crops and trees and its water consumption
State of the surface and sub-surface drainage system
Irrigation water sources and systems used
State of groundwater
Industrial facilities and waste disposal conditions
Sources of pollution and expected extend in activities (10 yrs)
Preliminary stakeholders analysis
Any other physical settings or matters arise
Any other arising matters

Annex (II)

Short description about the Med-Wet Project

Improving MEDiterranean irrigation and Water supply for smallholder farmers by providing Efficient, low-cost and nature-based Technologies and practices (MED-WET)

The Mediterranean region faces significant water scarcity which is further exacerbated by high tourist activities, population growth, changing food consumption patterns and climate change. Agriculture is the major water consumer and hence requires increasingly more efficient and sustainable irrigation technologies that are widely applicable and accepted by smallholder farmers. They must hence be low-cost, lean solutions that optimize natural resource use and income. This project- Improving Mediterranean irrigation and Water supply for smallholder farmers by providing Efficient, low-cost and nature-based Technologies and practices (MED-WET)- was developed to ultimately improve the irrigation efficiency of small farmers in the Mediterranean region especially through the optimal use of scarce water resources for lasting food and water security. One of the objectives of the MED-WET project is to develops productive constructed wetlands to transform communal or farming wastewater (wetland stage 1) into reclaimed irrigation water, which flows into the subsequent productive wetland units with special species crops (wetland stage 2). This enables farmers to directly utilize safe-for-reuse and nutrient-rich effluent for crop farming. Crop selection and placement is targeted to accommodate water and nutrient needs and tolerance. The Med-Wet project is funded by the EU. MED-WET has established a consortium of partners with the competence, commitment and vision to meet the requirements of this call. The consortium is composed of 5 universities, 1 non-profit RTO, and 2 public entities from 3 European and 2 North African countries, composed of experts in the agricultural sciences, engineering, environmental sciences, business & entrepreneurship, and policy. The MED-WET partnership also includes twelve indirect partners consisting of policy makers from the agricultural and economic sectors, farmer associations and individuals who support the project as members of the Advisory Board. Six field testing sites are planned in Portugal, Malta, Morocco and Egypt, in arid regions where climate change is already severely affecting agricultural production. All pilot sites involve farmers in participatory research, co-development, capacity-building and demonstration activities. Several MED-WET

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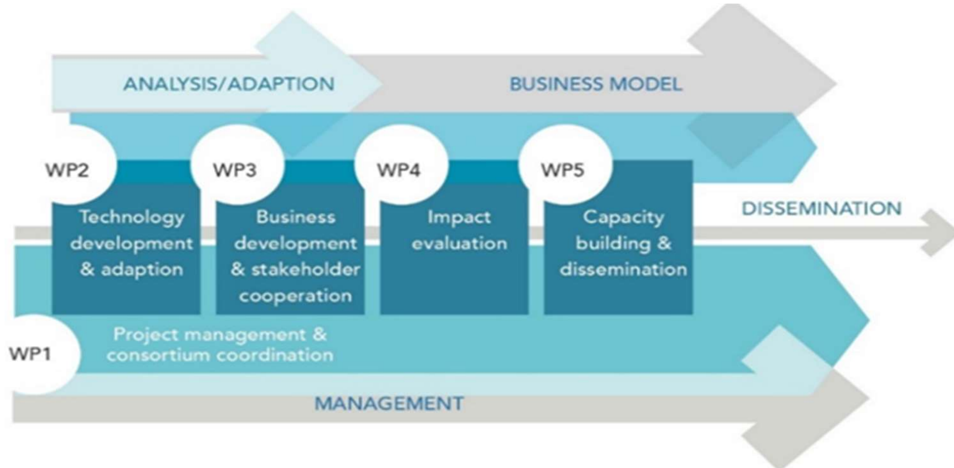
partners will combine their experience, and developed methods and established channels for capacity-building and agricultural extension services. The project follows a clear definition and progression of tasks structured in work packages (WPs). MED-WET organizes the planned activities under five work-packages. Each Work Package (WP) is assigned a Work Package Leader (WPL) and each Task assigned a Task Leader (TL). The WPs will be led and coordinated by the respective WPLs. They have been chosen based on their expertise in the specific areas required and are responsible for the successful delivery and the reporting assigned to their WPs.

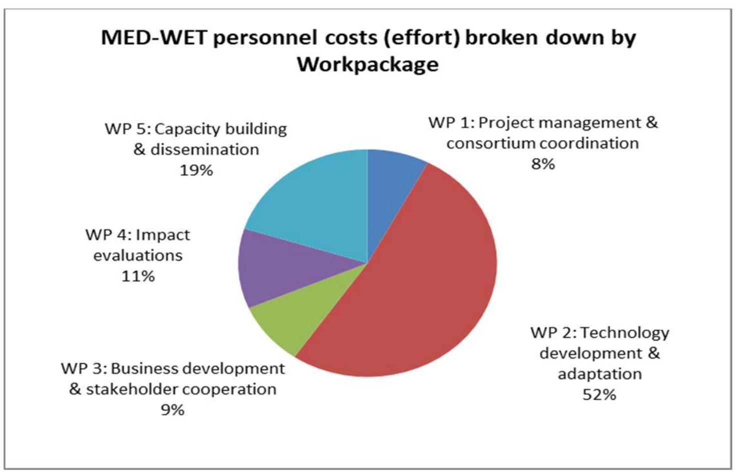
Med-Wet's overall budget is **1.25 million Euro**

Duration of the project : **3 years**

Start Date Nov., 2021

Closing Date: 31 Oct., 2024





The target of the MED-WET project in Egypt is to conduct applied research on constructed engineering instream wetlands. Expert team from the Water Engineering Program of HUSD, a partner of the MED-WET project, will lead the project pilot of the wetlands technology and contribute especially to the training components, publishing scientific papers and field visits, through its collaboration with farmer associations and inclusion of student internships and graduate research studies to ensure the project reaches the target groups as well as the beneficiary farmers. The motives for HUSD to carry out this research project component is the acute water scarcity Egypt is facing combined with the escalating water needs that drive the researchers and scientists to find new non-conventional water resources. Therefore, this research project aims to provide cutting-edge technologies of low-cost and affordable solutions to increase water resources by natural treatment of communal or farming wastewater into reclaimed irrigation water through a constructed wetland system.

Annex (III)

F A C T S H E E T

Low-cost and Nature-based Wastewater Treatment Technology in Rural Communities using Constructed Engineering Instream Wetland, Aeration Weirs, Native Plants and Micro-organisms

Traditional Wastewater Treatment:

Conventional wastewater treatment consists of a combination of physical, chemical, and biological processes and operations to remove solids, organic matter, some metals and nutrients from wastewater. It is common in all big cities and towns. It can receive large amounts of raw wastewater and treat it in short time, a day or two. The effluent treated water can be used in irrigating non-fruitful trees or non-edible crops like cotton. The conventional wastewater treatment includes several processes, such as: coagulation, flocculation, sedimentation, filtration, and activated carbon absorption, and activated sludge. Chlorination could be added for disinfect treated water.

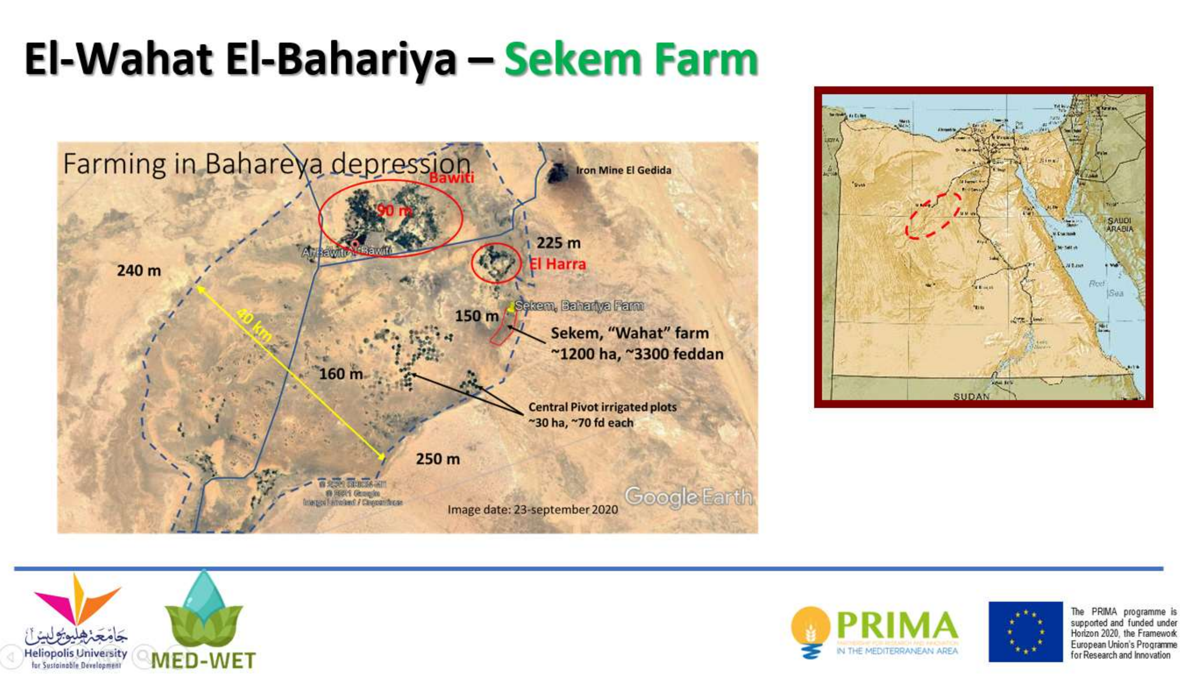
There are three stages in the traditional wastewater treatment: primary, secondary and tertiary. In the primary stage, solids are allowed to settle and removed from wastewater. The secondary stage uses biological processes to further purify wastewater. Sometimes, these stages are combined into one operation. Tertiary stage is only used when the effluent water might be in direct contact or used for human life so that disinfection process must be added to the secondary treatment to prevent any health impacts on humans. The efficiency of traditional wastewater treatment is adequate to prevent sever environmental pollution, however, its per cubic-meter cost is higher than the same amount of drinking water purification.

Constructed Wetland Treatment (Low-cost technology)

- Constructed wetland treatment (CWT) fits well the rural and desert communities because it is cheap, natural-based, and does not need energy nor sophisticated technicians, if compared to conventional wastewater treatment. Also it readily can be constructed in remote areas.
- CWT is efficient in treating municipal effluents, agricultural drainage, animal wastes, which are the most common in such remote communities. CWT uses native special weeds, soils, microorganisms and aeration weirs to remove contaminants from wastewater by mimicking the processes in natural wetland ecosystems.

HU, Egypt Pilot (Constructed Engineering Instream Wetland treatment site in El-Wahat El-Baharia) under MedWet Project

- ✓ HU is designing, constructing and operating a research pilot, which is **Constructed Engineering Instream Wetland Treatment (CWT) site** under the MED-WET Project in El-Wahat El-Baharia, western desert of Egypt. It is state-of-the-art in using low-cost, nature-based and efficient technology for wastewater treatment.



- ✓ **What does CWT mean?**

  It is managed by water engineers to assure proper technical implementation. It is longitudinal channel trapezoidal cross-section with shallow depth, low speed water flow and lined bed and sides to prevent pollution transfer to the groundwater aquifer. It is provided with "substrate medium" that functions to naturally treat the polluted water. Substrate supports rooted and floating vegetation. It consists of native species of plants/weeds, biofilms, soil, micro-organisms and organic letter, in which aerobic and anaerobic reactions occur. The water flow is operated by natural gravity without energy consumption (cheap technology). This technology has proven high efficiency in treating domestic/municipal wastewater as well as agricultural drainage water for remote rural and desert communities in Egypt.

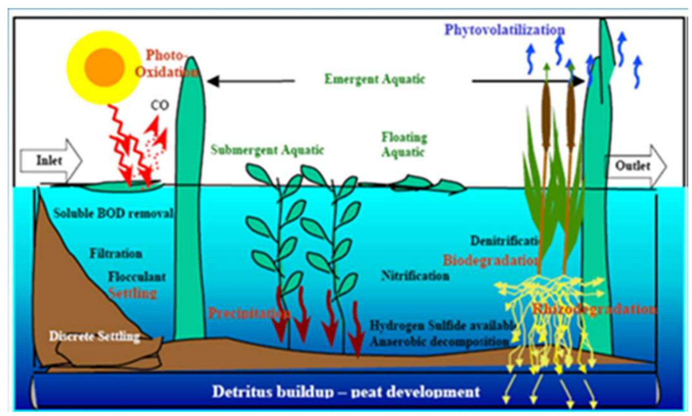
<u>CWT systems are capable of removing:</u>

- ✓ **Nitrogen and phosphorus**
- ✓ **Biochemical oxygen demand (BOD)**

- ✓ **Chemical oxygen demand (COD)**
- ✓ **Total suspended solids (TSS)**
- ✓ **Metals and heavy metals**
- ✓ **Toxic compounds (e.g., cholorophenols, chlorinated resin and fatty acids)**
- ✓ **Viruses, bacteria, algae and pathogens from wastewater.**

<u>Benefits of implementing a CWT pilot in remote area (El-Wahat El-Baharia):</u>

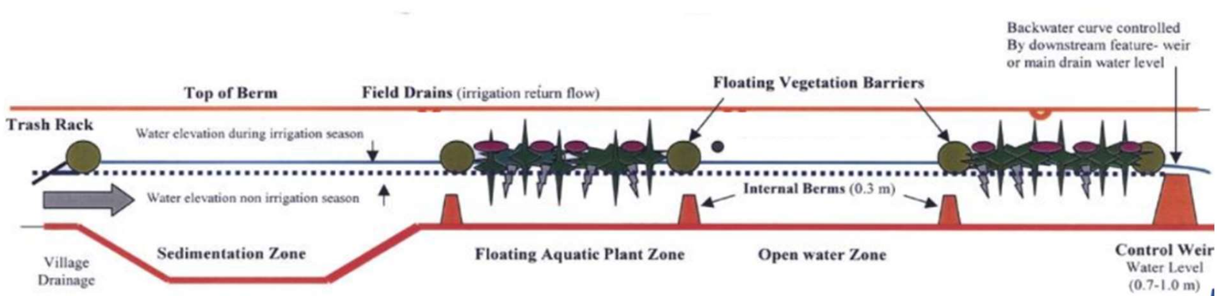
- ✓ **New cheap and efficient water resource (non-conventional) that increases the available water resources for isolated rural and desert communities.**
- ✓ **Reclamation of simple forms of nutrient effluent for irrigation purposes.**
- ✓ **Preserve the groundwater and surface lakes from pollution, so it reduces the environmental impacts.**
- ✓ **Useful for safe sludge management and on-site reuse, because of its zero wastes**
- ✓ **Good application of the circular economy concept for the smallholder farmers, and thus supports the local business creation and smallholders' irrigation in remote communities.**



<u>Conceptual Design of CW</u>

The CWT pilot (instream-wetland system) includes wastewater tanks, treated water tanks, lined channels, treatment substrate (soil, plants, weeds, micro-organism, …etc.), weirs, pipes, valves and filters as needed.

Research Objective: is to determine the highest treatment efficiency



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