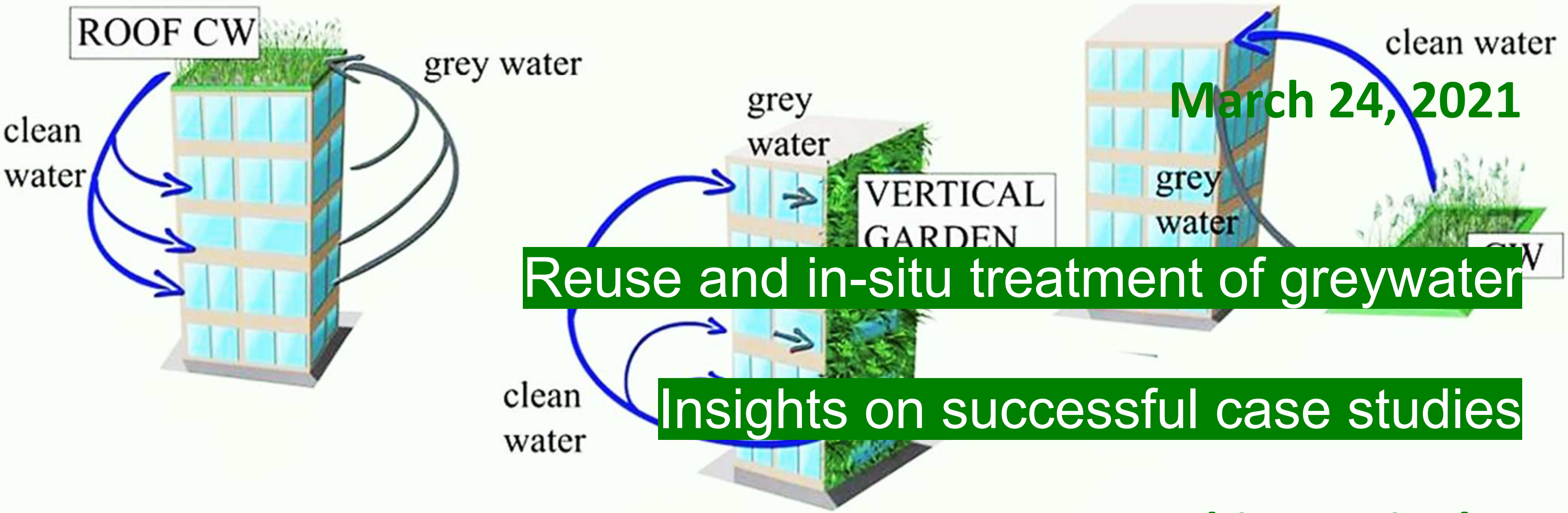
UNALAB CITIES WEBINAR #7

NBS for circular water systems



March 24, 2021

Reuse and in-situ treatment of greywater

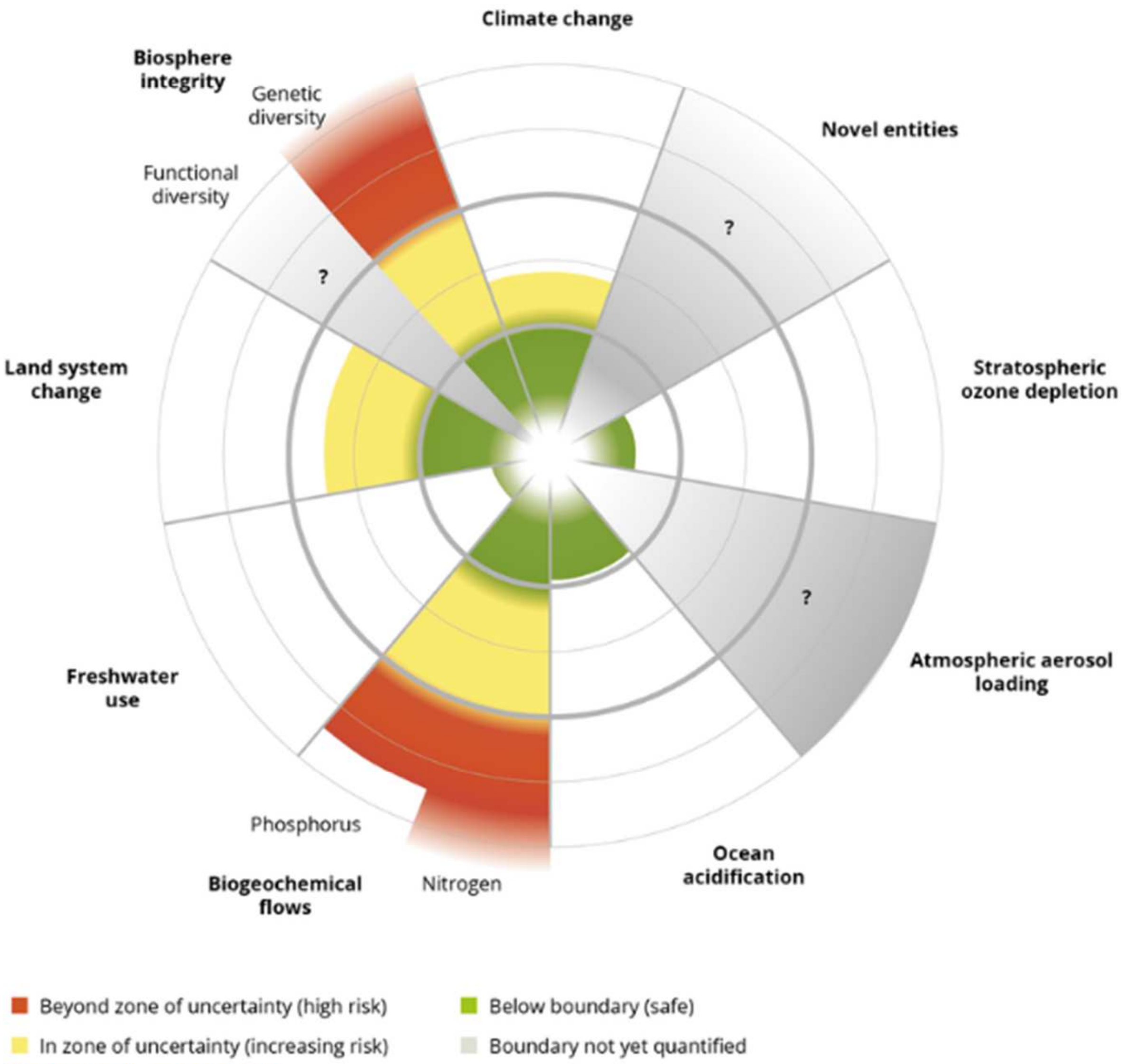
Insights on successful case studies

Dr Fabio Masi, PhD
R&D Manager IRIDRA

Status of the nine planetary boundaries

Infographic — Prod-ID: INF-140-en — Published 05 Dec 2019 — Last modified 11 May 2020 PDF

Topics: Environment and health | Air pollution



European Environment Agency

Related content

Loss of biodiversity

Increase of flood events

Increase of heat islands

Worsening of water quality

Increases of droughts

Social challenge: Climate change
Some climate risks

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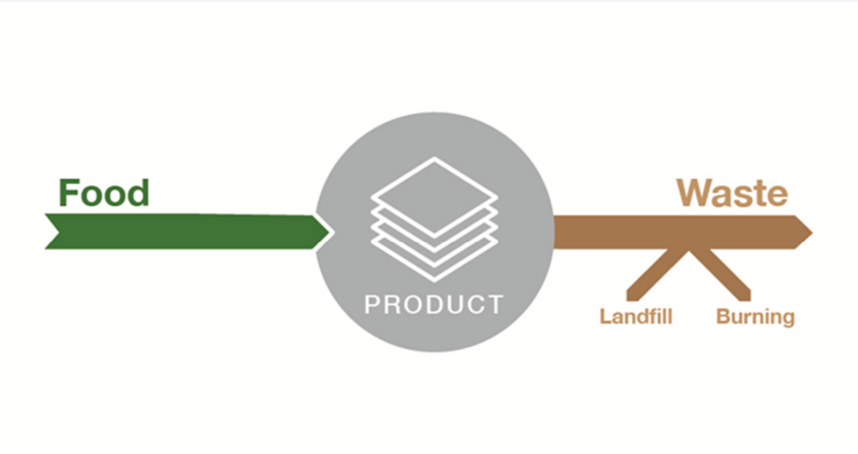
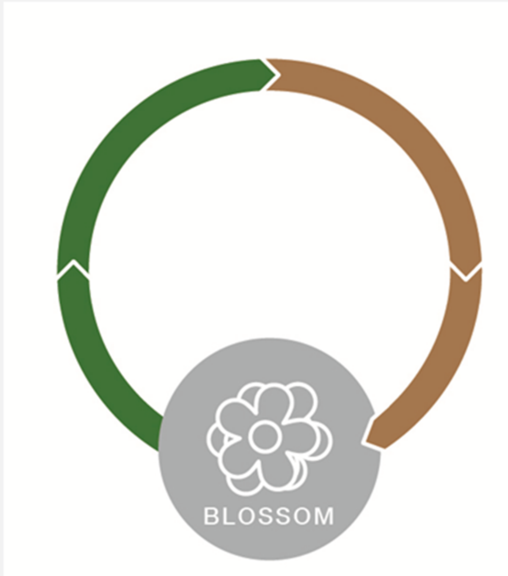
The Water Cycle
in the Sustainable Development Goals
6.5
Water resources management
6.4
Water use and scarcity
6.6
Ecosystems
11.5
Water-related disasters
6.a-6.b
Cooperation & participation
6.3
Water quality and wastewater
6.1
Drinking water
6.2
Sanitation and hygiene
UN WATER
SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD

THE ECOLOGICAL TRANSITION BASICS

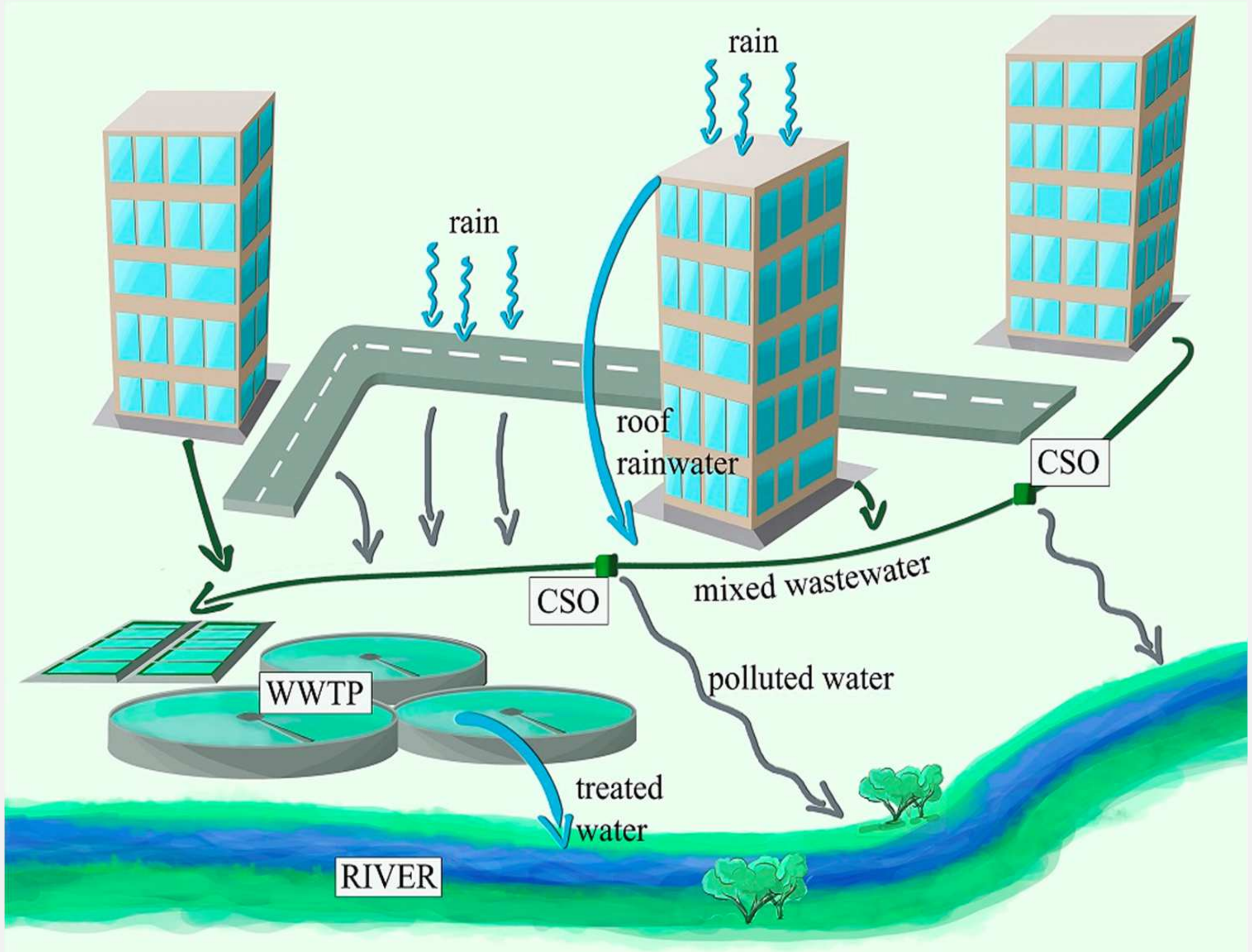
The linear approach:
Take, make and dispose



The circular approach:
'Waste is food'

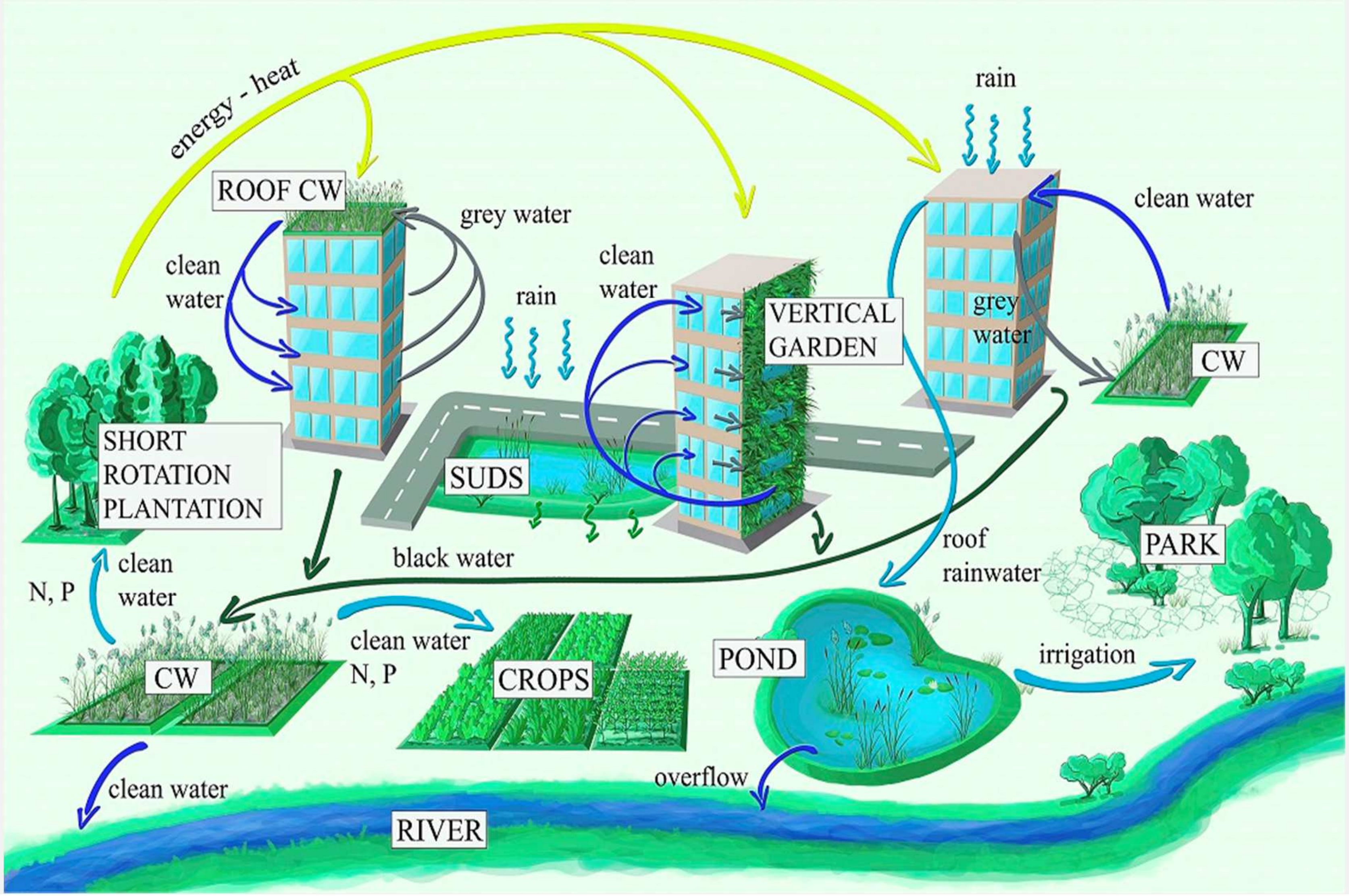


THE PRESENT
Conventional scheme



Fonte: Masi et al. (2018)

The smart circular city of the future (next?)



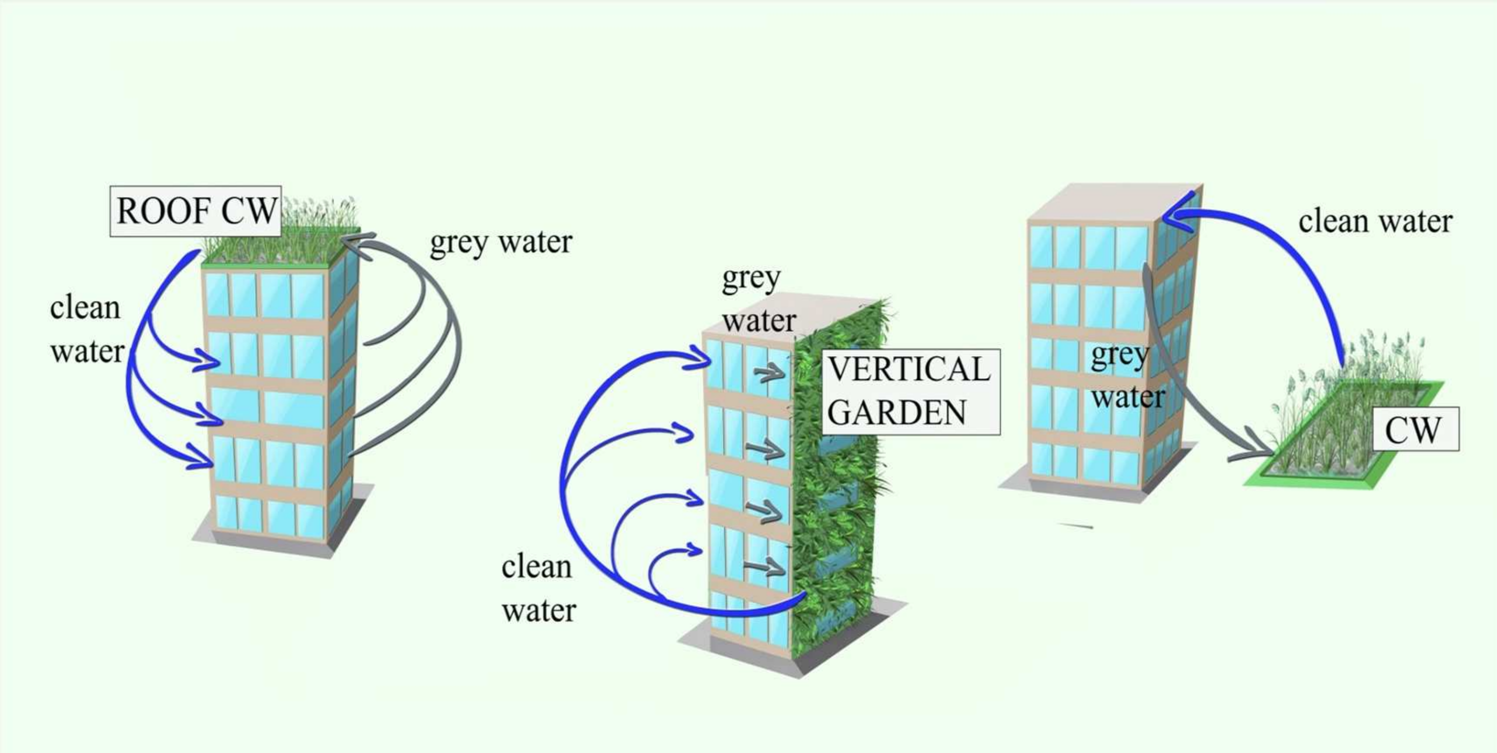
Assets for climate change adaptation: the 3 pillars

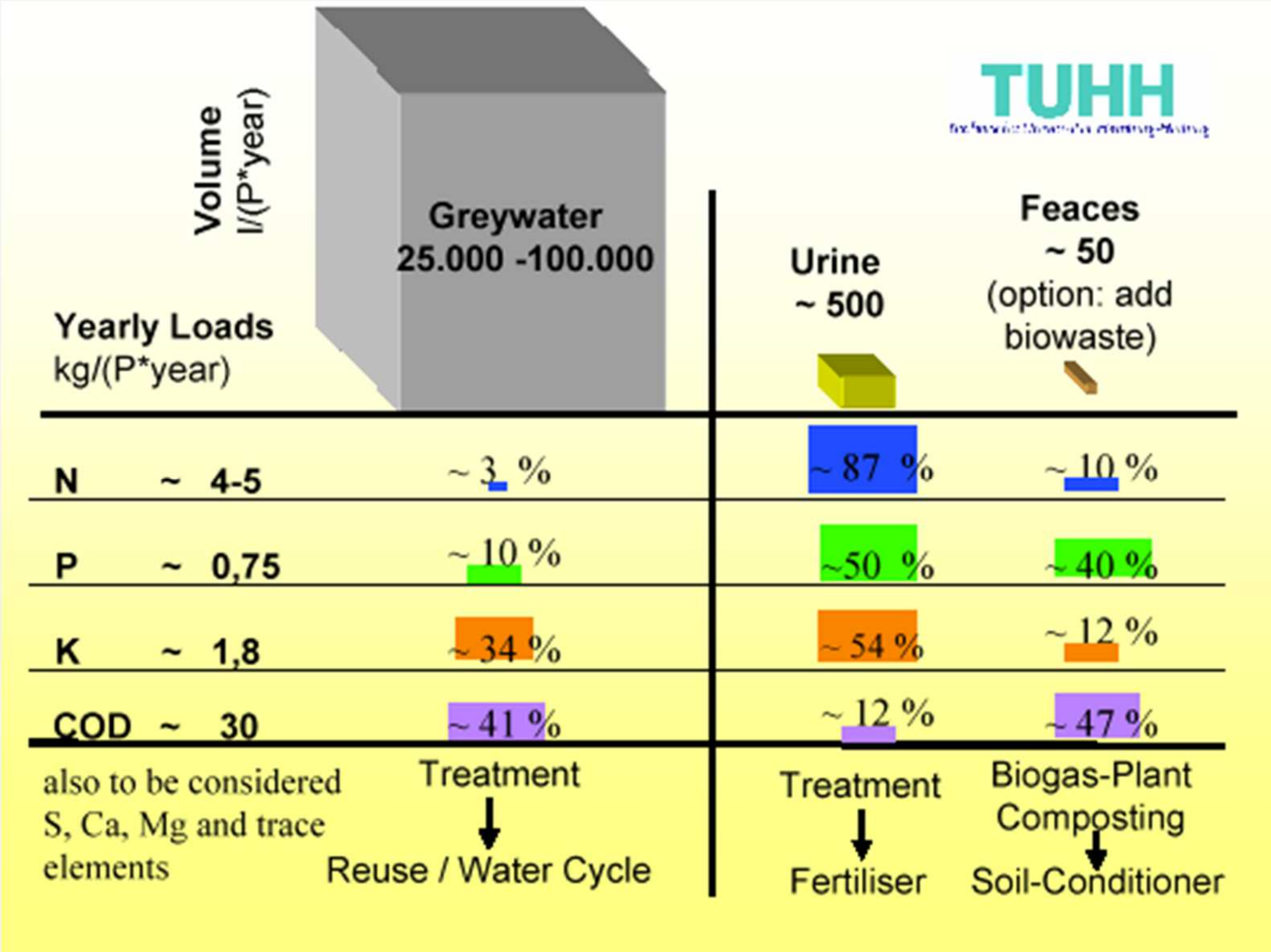
- A smart decentralisation decreases R, more flexible and resilient network and also more circular
- NBS as tertiary treatment / buffer step or for CSO treatment (additional function removing CECs)
- **Water supply integration** by the use of NBS for **recycling greywater** and harvesting rainwater

Circular economy and ES scheme

Greywater close-loop recycling

Big saving in water supply demand (easy to reduce by 50%)





- Dense urbanisation, often no area for NBS solutions
- Lack of land for centralised treatment plants
- Availability of greywater – **100 lt/pe.day**

WHY GREYWATER RECYCLING?

- With the exclusion of excreta-contamined water (blackwater) all the domestic consumption can generate greywater, up to **70-75% of the total** every single day
- Much **more biodegradable** and with **faster kinetics** for the organic compounds degradation
- The **demand** of recycled water can be easily **linked to** the **production capacity** (close loop decentralized approach)
- Extremely **high economic advantages** in not mixing it with the blackwater, especially in terms of **Natural Capital conservation**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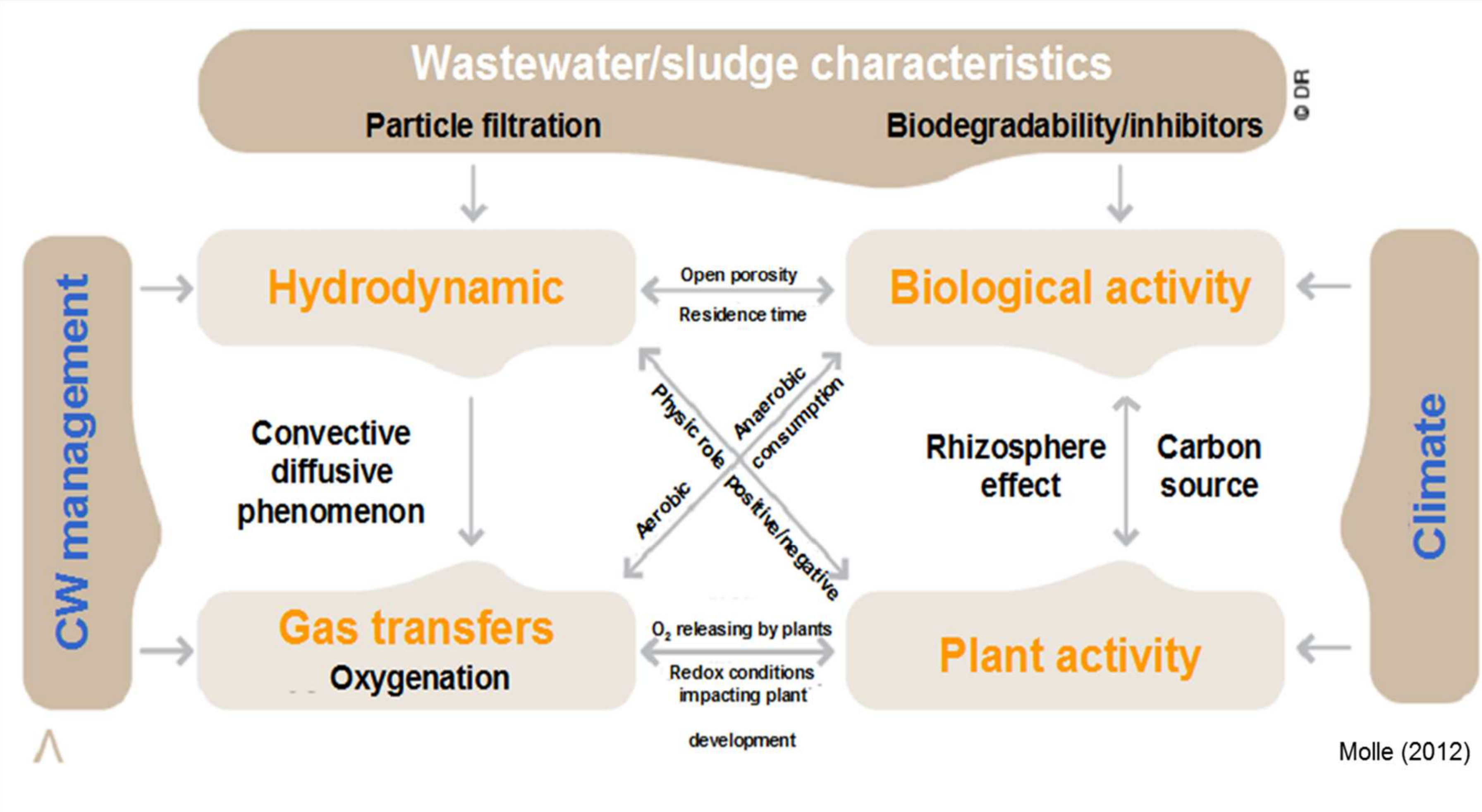
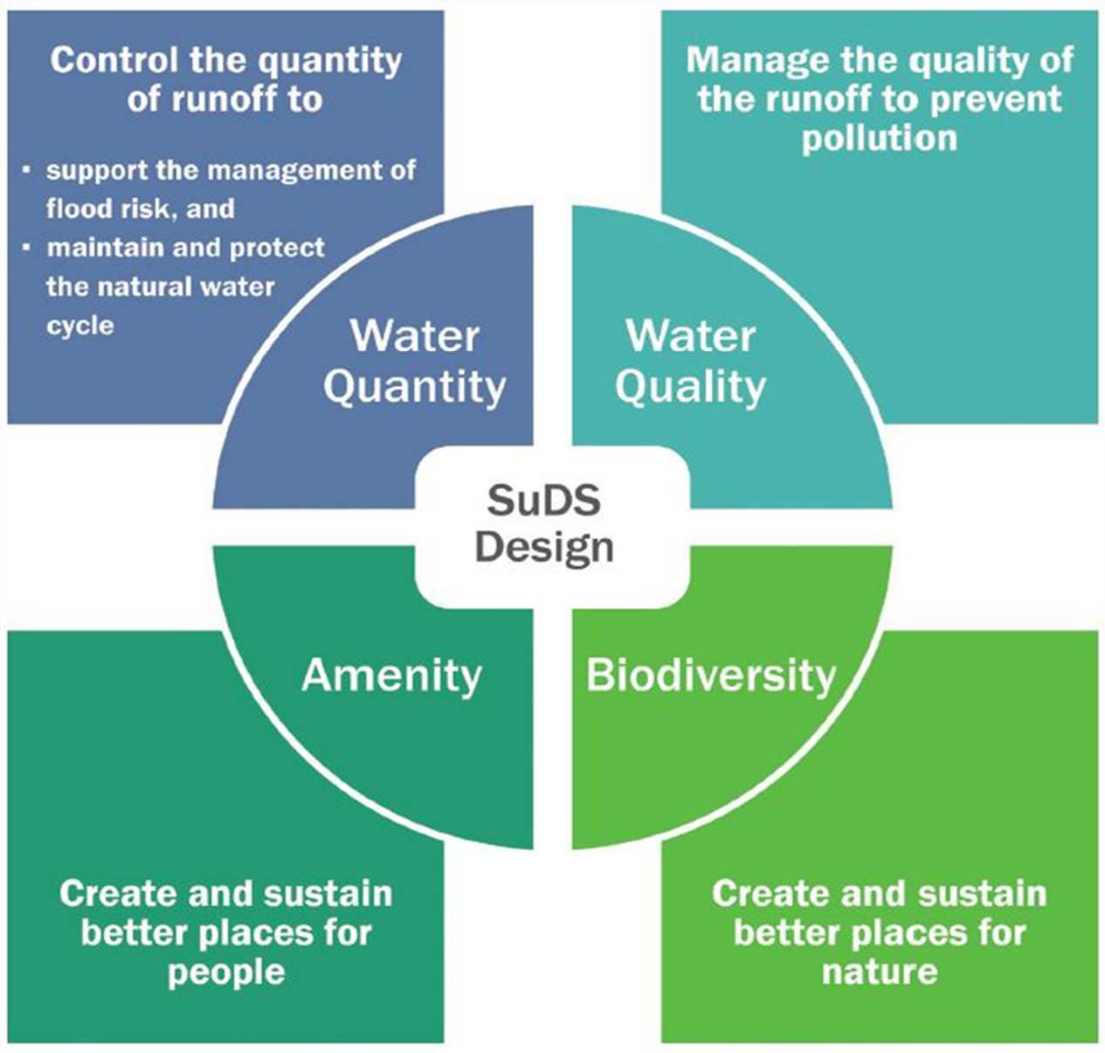
Constructed Wetlands
A complex equilibrium



Multipurpose Design



Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

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"Tentative" list of NBS co-benefits

Biodiversity increase

Flood mitigation

Aesthetic and Landscaping

Heat island reduction

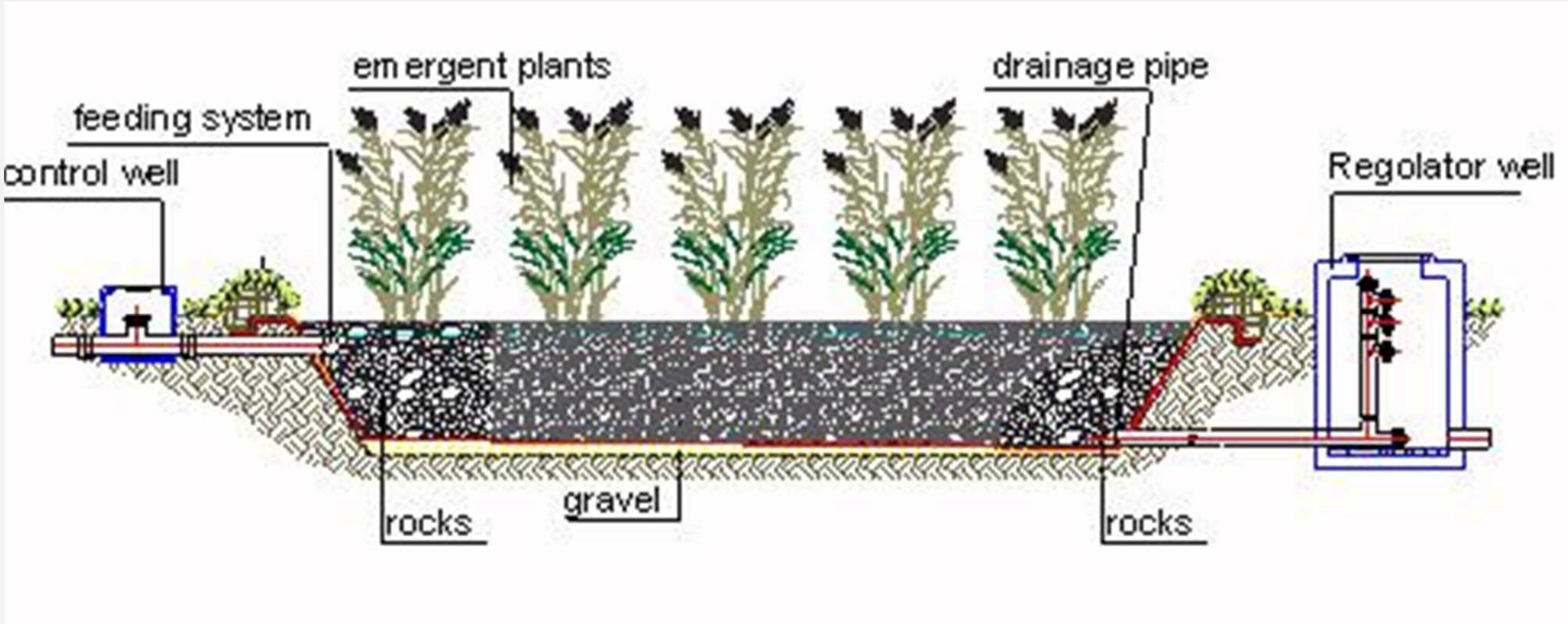
Water recovery

Nutrient recovery

Energy recovery

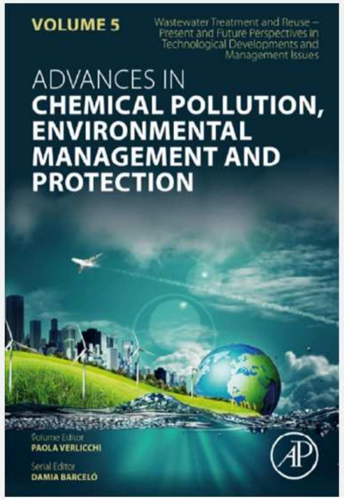
CO_2 storage

Greywater Treatment: HF CWs



Circular economy and ES scheme

Greywater recycling outdoor



CHAPTER FOUR

Possibilities of nature-based and hybrid decentralized solutions for reclaimed water reuse

Fabio Masi[a], Guenter Langergraber[b], Marcello Santoni[a], Darja Istenič[c], Natasa Atanasova[d], and Gianluigi Buttiglieri[e,f,*]

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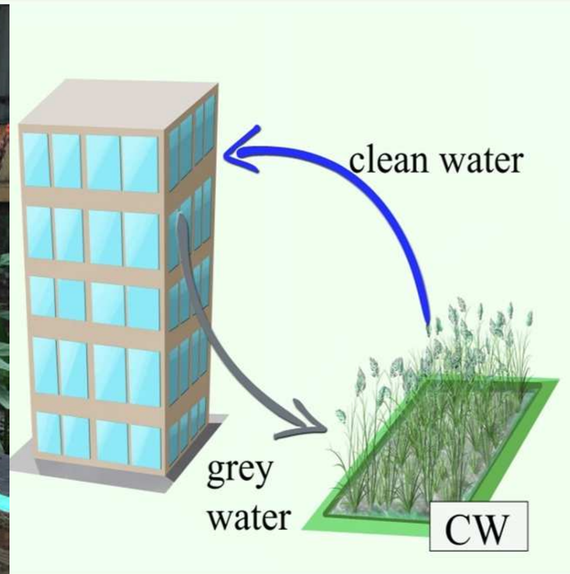
[b]Institute of Sanitary Engineering and Water Pollution Control, University of Natural Resources and Life Sciences, Vienna (BOKU), Vienna, Austria
[c]Faculty of Health Sciences, University of Ljubljana, Ljubljana, Slovenia
[d]Faculty for Civil and Geodetic Engineering, University of Ljubljana, Ljubljana, Slovenia
[e]Catalan Institute for Water Research (ICRA), Girona, Spain
[f]Universitat de Girona, Girona, Spain
*Corresponding author: e-mail address: gbuttiglieri@icra.cat



Hostel campus of the College of Engineering, Pune (India):

40 m3/d

38000 m3 of tap water saved in 2019 (for a value of about 7500 USD)

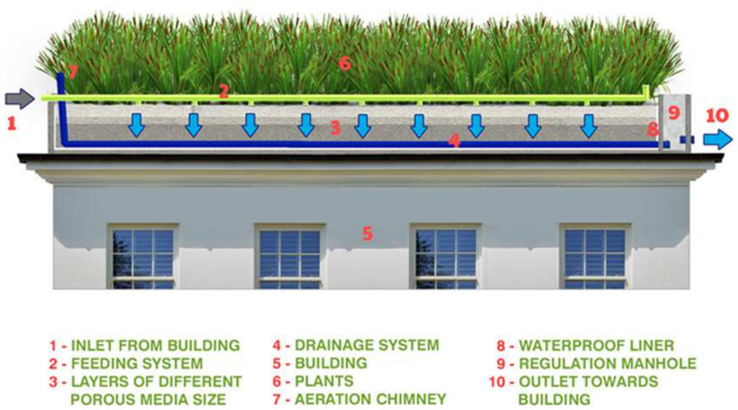
Circular economy and ES scheme

Greywater recycling outdoor

Beduine Village in Westbank, Palestine: 70-120 pe. Segregation, treatment and reuse of greywater for irrigation of olive trees and bushes for goats fodder. About 1500 m3 of water per year produced for irrigation

Circular economy and ES scheme

Greywater recycling by rooftop biofilters/wetlands



Circular economy and ES scheme

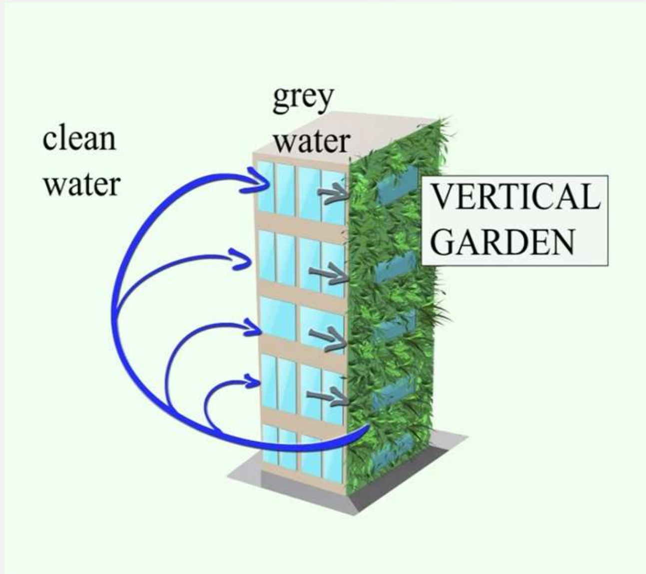
Greywater recycling by rooftop biofilters/wetlands

Resort in Grumenti community,

Serengeti Park (Tanzania): 4 m3/d

Circular economy and ES scheme

Greywater recycling by Greenwalls



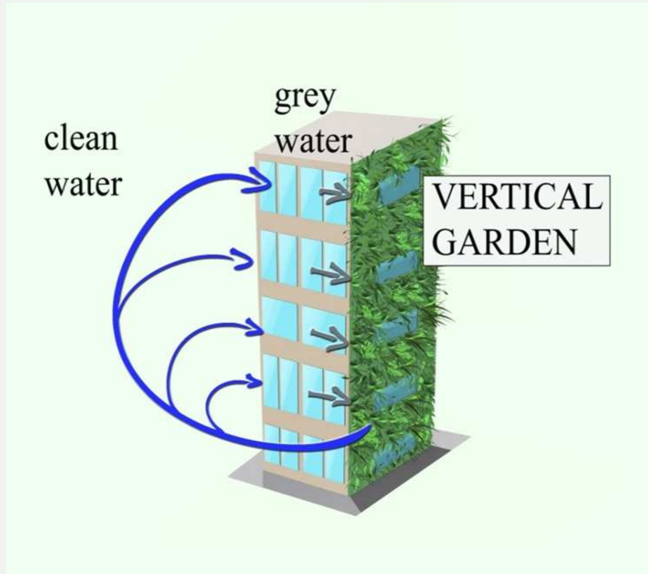
Green walls / VERTICAL GARDENS

- Air filtration + O_2 production and CO_2 storage
- Reduced energy costs + positive microclimate effects
- Increased biodiversity
- Reduced noise pollution
- Increased building longevity
- Aesthetics

◆ Wastewater treatment?

Circular economy and ES scheme

Greywater recycling by Greenwalls

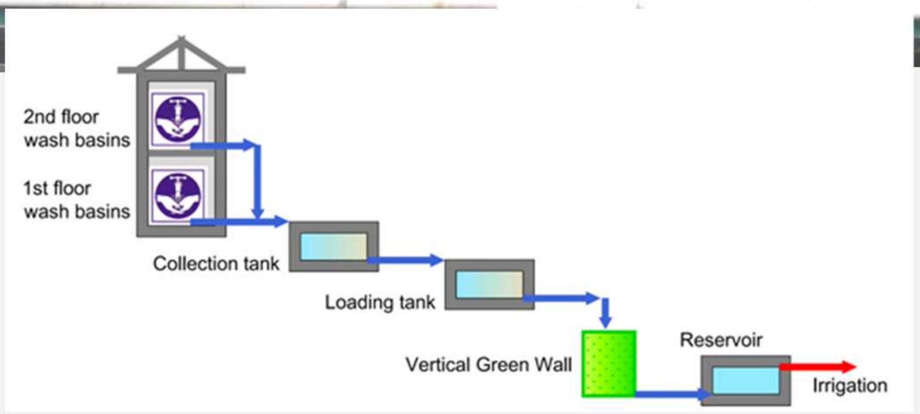


Beach resort Marina di Ragusa (Italy)


IMAGINE IF TREES
GAVE FREE WIFI.
WE'D ALL BE PLANTING
LIKE CRAZY.
IT'S A PITY THEY ONLY
GIVE US THE OXYGEN
WE BREATHE.

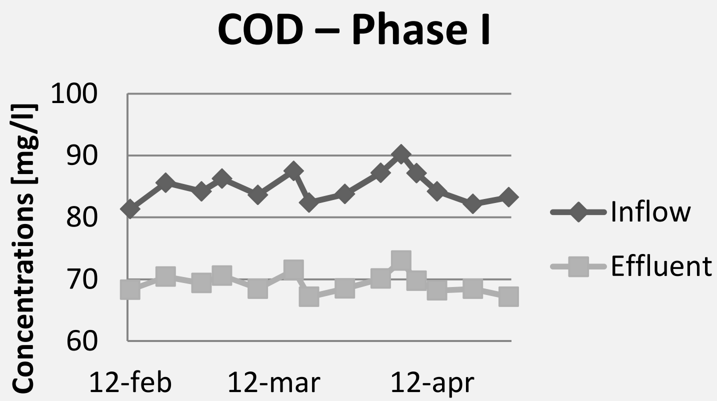
Maharashtra Jeevan Pradhikaran (PUNE) VERTICAL GARDEN FOR GW TREATMENT - experimental setup

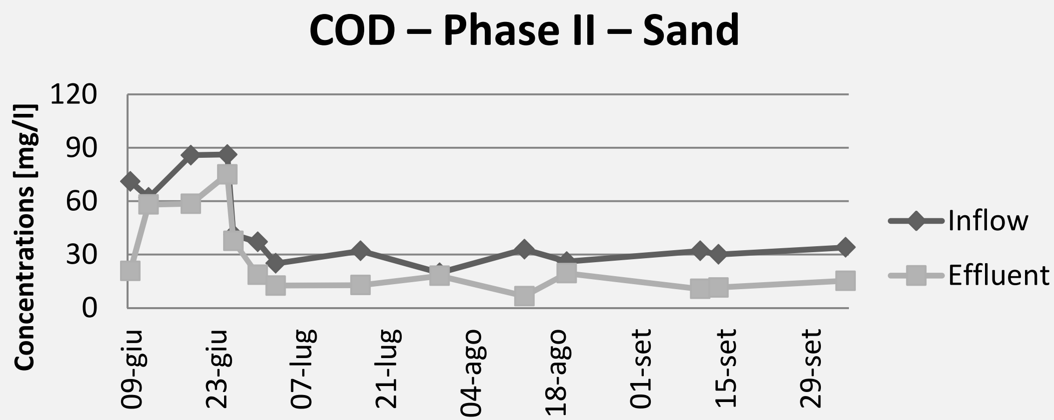
- Pots filled by: line 1- LECA+Cocopeat line 2 – LECA+Sand

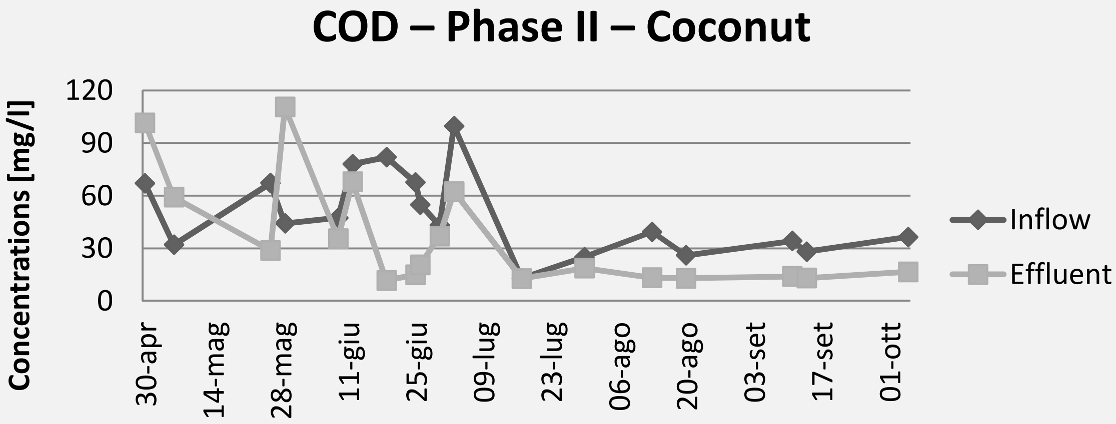


Mjp pune results

- LECA (0-4 mm) alone (Phase I) makes the influent flashing down too fast and the performances are not satisfactory
- The mix of LECA with Cocopeat or Sand improves the performances to an acceptable level
- Cocopeat offers advantages over Sand: weight, cost, source of nutrients, ...







SUPERGREEN
(*SUstainable Purification of wastewatER with GREEN walls*) project financially supported by
Compagnia di San Paolo.

CW for greywater: **SUPERGREEN**

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ELSEVIER

Review

A review of nature-based solutions for greywater treatment: Applications, hydraulic design, and environmental benefits

Fulvio Boano [a,*], Alice Caruso [a], Elisa Costamagna [a], Luca Ridolfi [a], Silvia Fiore [a], Francesca Demichelis [a], Ana Galvão [b], Joana Pisoeiro [b], Anacleto Rizzo [c], Fabio Masi [c]

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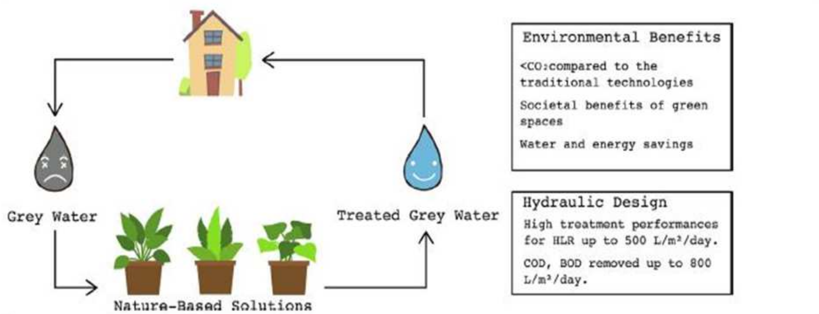
HIGHLIGHTS

- Nature-based solutions (NBS) are a viable option for greywater (GW) treatment.
- Review of case studies provided numerical thresholds for hydraulic design of NBS.
- Life cycle assessment studies demonstrated the benefits of NBS for GW treatment.

GRAPHICAL ABSTRACT



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TÉCNICO LISBOA

CW for greywater: SUPERGREEN + NICE

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ACS ES&T Water

pubs.acs.org/estwater

Article

Assessment of the Treatment Performance of an Open-Air Green Wall Fed with Graywater under Winter Conditions

Fulvio Boano,* Alice Caruso, Elisa Costamagna, Silvia Fiore, Francesca Demichelis, Ana Galvão, Joana Pisoeiro, Anacleto Rizzo, and Fabio Masi

Cite This: https://dx.doi.org/10.1021/acsestwater.0c00117

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ABSTRACT: Graywater (GW), i.e., the portion of household wastewater that excludes toilet flushes, is an interesting wastewater type because it requires only mild treatment. Green walls have been proposed as example of a nature-based solution for GW treatment due to low energy requirement and high ecological/societal benefits; however, indications about their treatment performances remain limited. This work presents experimental results of a laboratory modular green wall for GW treatment. Experiments have been performed outdoors during the winter season for three months. Each panel included four vertical columns of planted pots, and it was fed with 100 L of synthetic GW per day. Removal efficiencies were as follows (average values): 40% chemical oxygen demand, 97% biochemical oxygen demand, 61% total Kjeldhal nitrogen, 56% NO_3^--N, 57% total phosphorus, 99% *Escherichia coli*, and 63% anionic surfactants. This work proved the potential of an open-air green wall for treating GW, even under challenging conditions for biological treatment processes and with high hydraulic loading rates.

Advantages
- Environmental, social and economical benefits
- Low energy impact
- Local water reuse

System properties
- HLR = 740.8 L/m²/d
- Growing medium coconut fiber and perlite

Outdoor green wall
- Vertical flow
- Modular panels
- 12 pots/m²

KEYWORDS: *green wall, graywater, reuse, nature-based solution, treatment*

European Commission

NICE: INNOVATIVE AND ENHANCED NATURE-BASED SOLUTIONS FOR SUSTAINABLE URBAN WATER CYCLE

Laboratory setup

- **Base medium:** Different **mixes of coconut coir (C) and perlite (P)** (Prodanovic et al., 2018) were tested to identify a good compromise between drainage time and specific weight.

Coconut

Perlite

TESTED MIXES:

- 90% C – 10% P
- **80% C – 20% P**
- 70% C – 30% P
- 60% C – 40% P

- The introduction of **additional materials** for enhancing treatment was also tested:
  - compost: 20%
  - polyacrylate (hydrogel): 20%
  - biochar: 20%
  - biochar + polyacrylate: 20% + 20%
  - activated carbon: 10%

Laboratory setup

- Pilot system: **6 metallic panels** (1m x 1m), with a **3 × 4 matrix of pots** filled with different growing media.

SUPERGREEN results

- **Our pilot system was tolerant to GW up to HLR=700 L/m²/d (very high, VF CWs usually designed for 80 L/m²/d)**

- **The best performance was achieved for BOD and E. coli, with removal efficiency close to 100%.**

- **COD removal was initially lower but increased over time (possibly due to biological effects).**

- **TN and TP show limited removed, but inflow concentrations were low.**

- **In view of Italian legislation limit**
  - **COD, BOD5, and TN met**
  - **E.Coli not met even with very high efficiencies → tertiary disinfection unit (e.g. UV lamp) needed, as usually done for reuse of wastewater treated by NBSs**
- **Removal efficiency (e.g., COD) may improve by adding biochar (and polyacrylates)**

CW for greywater: NAWAMED

NAWAMED PILOTS

NAWAMED

Expected results / Total flows to treat: 9.000 m3/year

	Italy	Tunisia	Jordan		Lebanon	
Targeted flows	2.000 m³/year	1.100 m³/year	2.500 m³/year		3.300 m³/year	
GW vertical surface	Ferla 64 m²	Cité Jardin 120 m²	Jerash 120 m²	Amman 170 m²	Beirut 200 m²	
CW storm water	Latina 1000 m²					
CW grey water horizontal + CW Aerated Vertical					Bekaa Valley 100 m²	Refugee camp portable system 12 m²
Estimated costs (infrastructures)	€ 140.000 € 76.800	€ 60.000	€ 162.000		€ 231.000	

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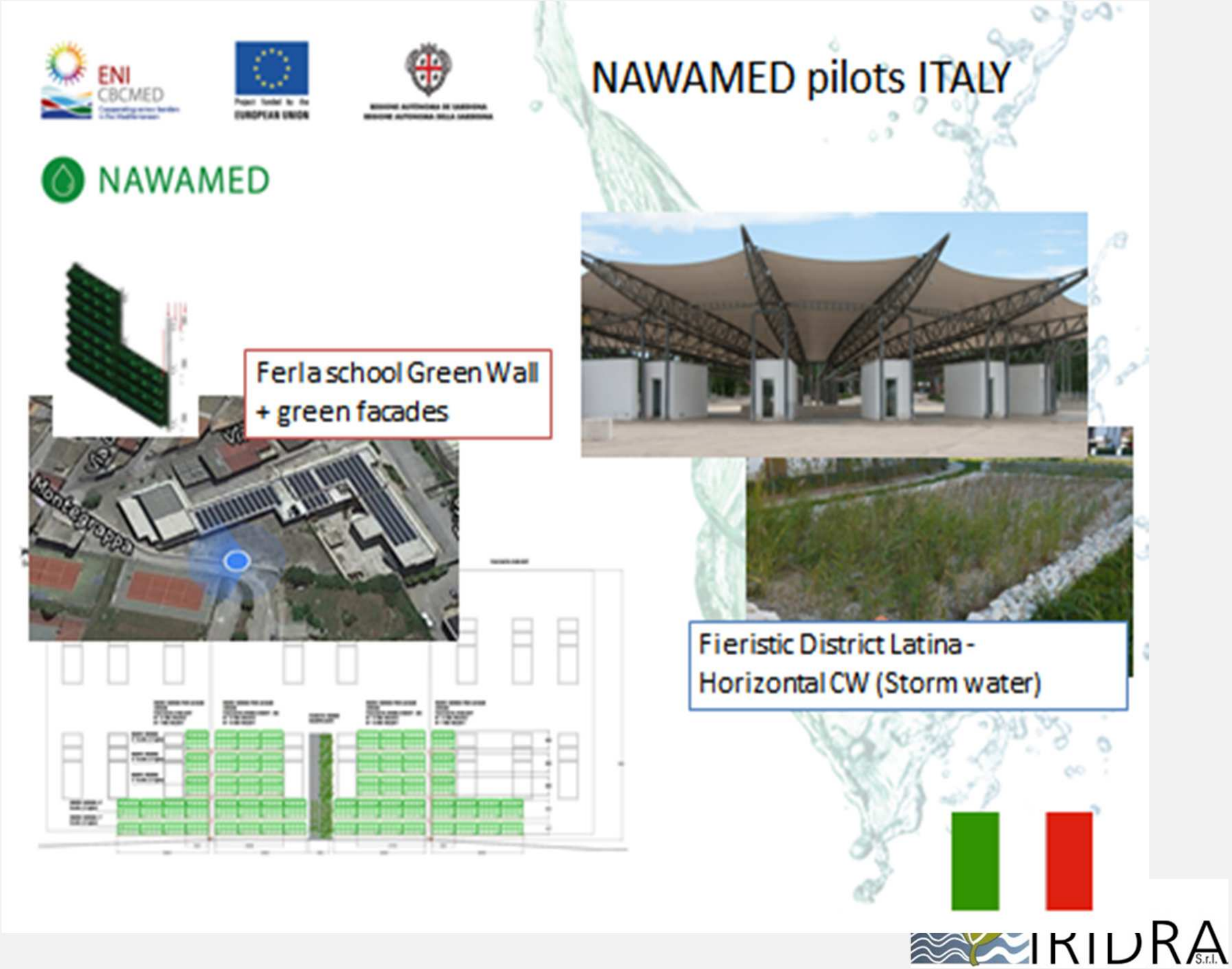
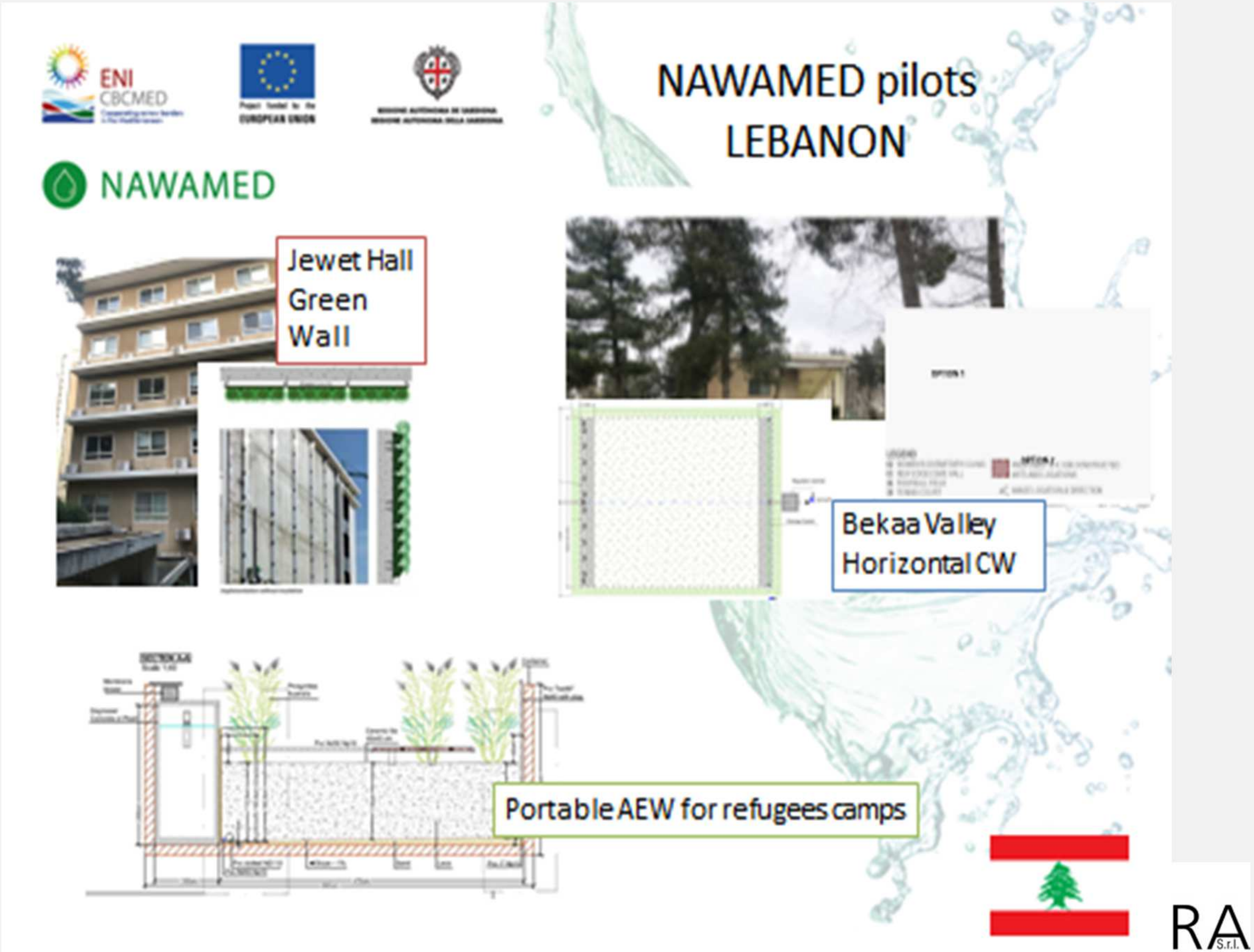
CW for greywater: NAWAMED



CW for greywater: NAWAMED



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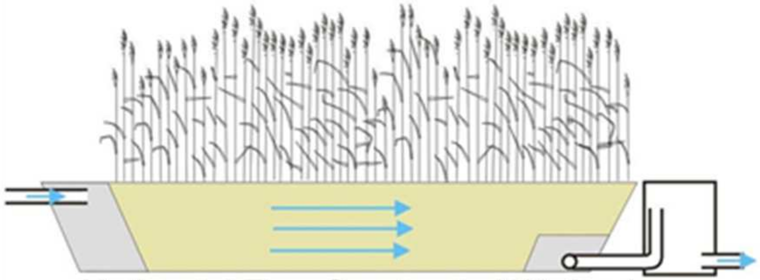
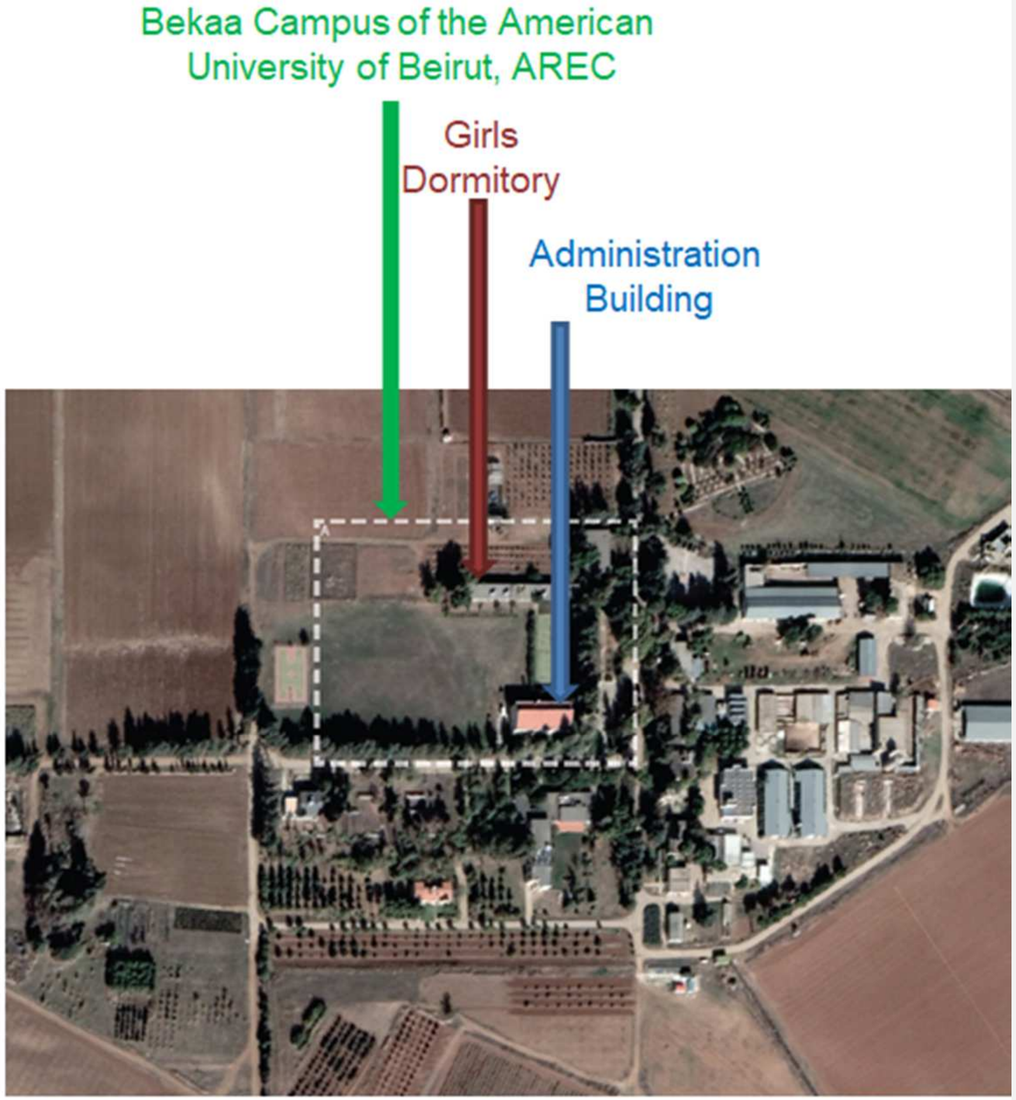
Case Study –General description



Horizontal Flow Constructed Wetland

Implementing a Constructed Wetland

Womens' dormitory & Edgecome Hall



Case Study –General description

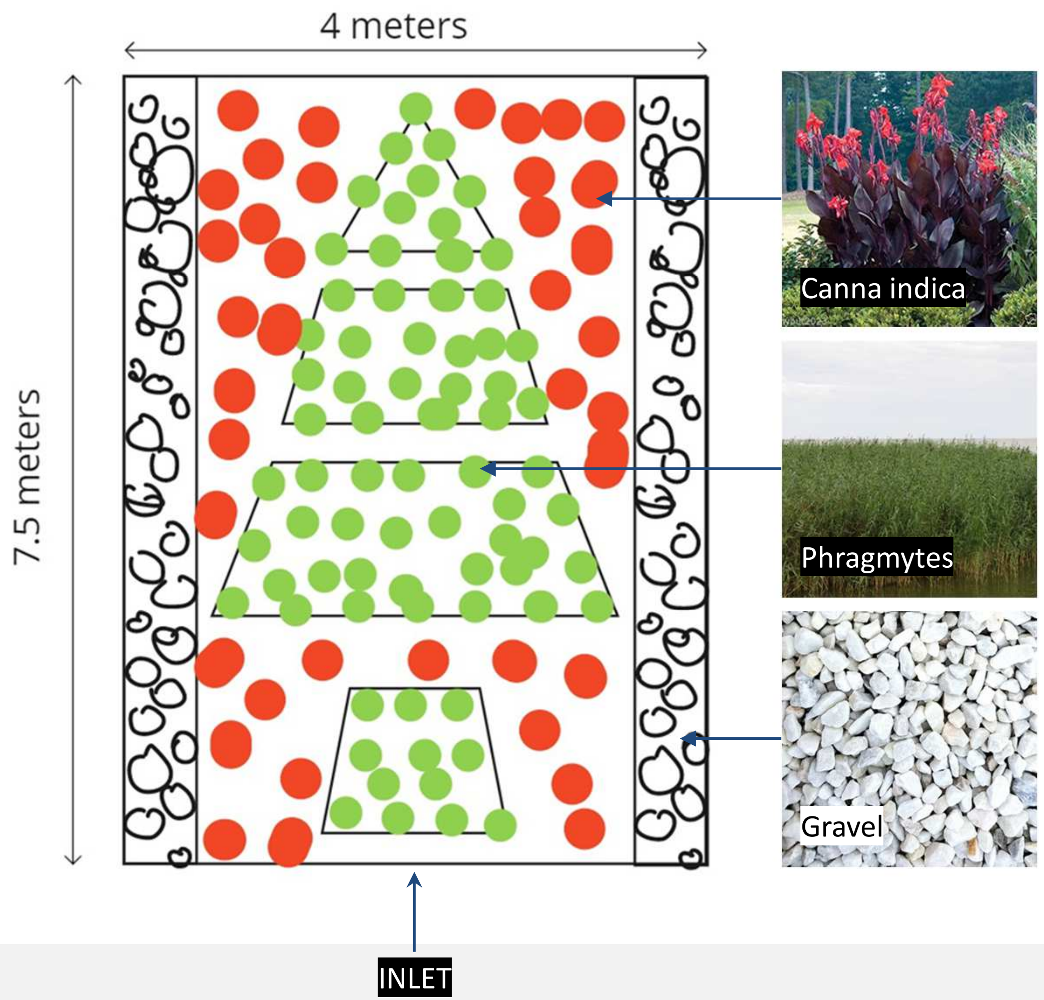
10 Officers and Staff

20 Students in the Girls Dormitory

12 Month Timeline	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temp. (°C)	12	12.7	14	17	20	23	25	26	24.9	22	18	14
Min. Temp. (°C)	8.2	8.9	10	12.6	16	19	21	22	20.7	18	14	10
Max. Temp. (°C)	15.8	16.5	18	21.4	25	28	29	30	29.1	27	23	18
Rainfall (mm)	193	147	119	57	19	2	1	1	10	52	112	171
935.1ET0 (mm)	21.9	26.6	36.6	58	88.5	123.8	142.4	145.1	121.6	87.5	53.7	29.4

WATER CONSUMPTION		
Dormitory	Q (l/cap/d)	C BOD5 (mg/l)
Total water consumption	80	
Black water	15	
Grey water	65	150
Washbasin	20	
Laundry and shower	45	
Laundry	5	1300
Shower	40	120

Case Study – Final results



Why this Design?

- Limit the surface area to minimize evapotranspiration
- Land availability – lower water height
- Climate change resilience

How much Water reuse and Energy savings?

- 287 m^3/yr → 47 800 toilet flush
- 4 302 m^3/ 15 yr
- Energy from public grid to pump tap water from the tank
- Energy consumption for water-truck transportation
- CO_2 release of +/- 15 500 kgCO_2/15 yr (truck)

CW for greywater: NAWAMED

NAWAMED

NAWAMED pilot
TUNISIA

Case Study –General description

SWM House- Green wall

6 CLEAN WATER AND SANITATION

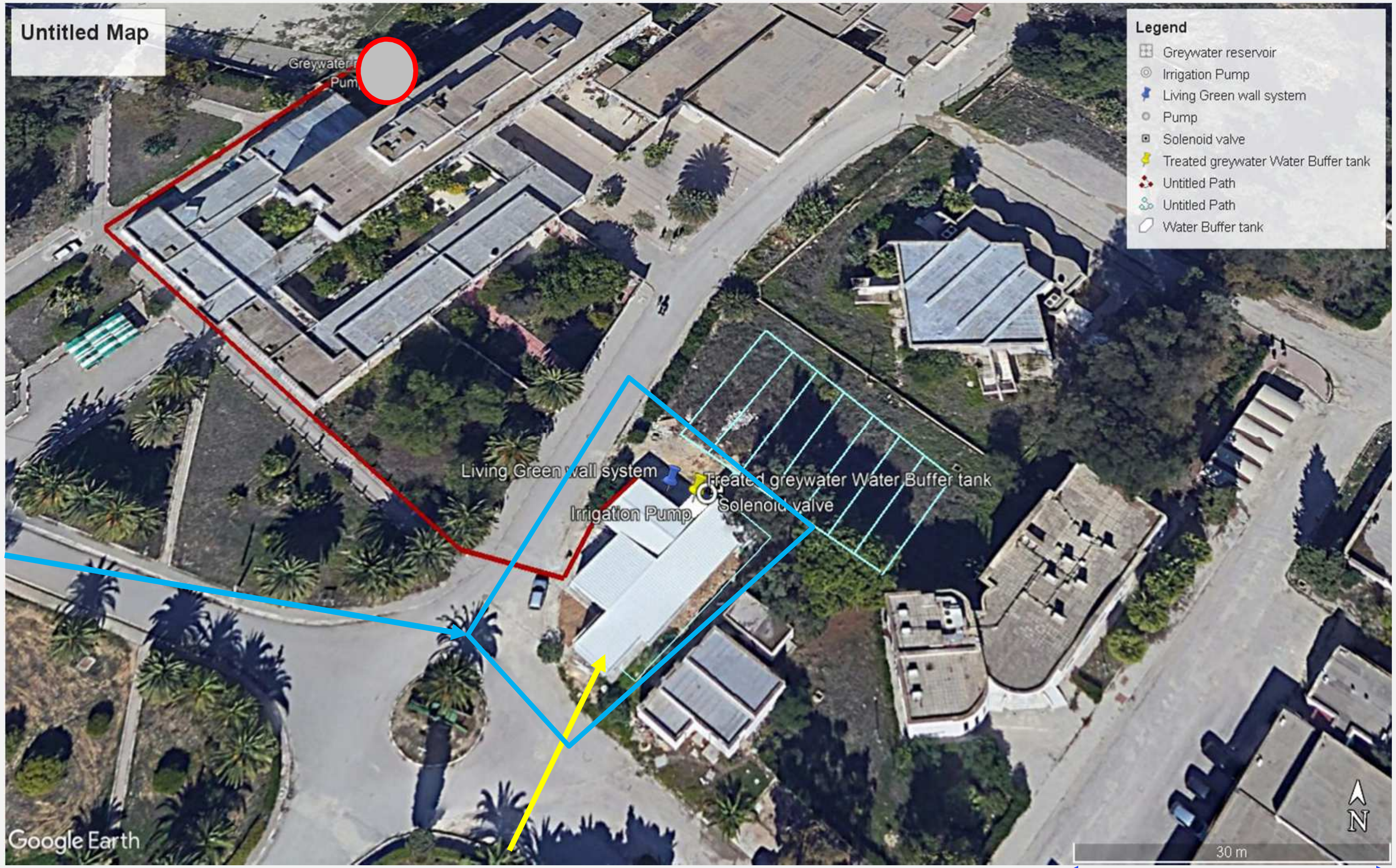
11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

Google map **Position**:
36°49’53”N ; 10°10’56”E

Pumping setup

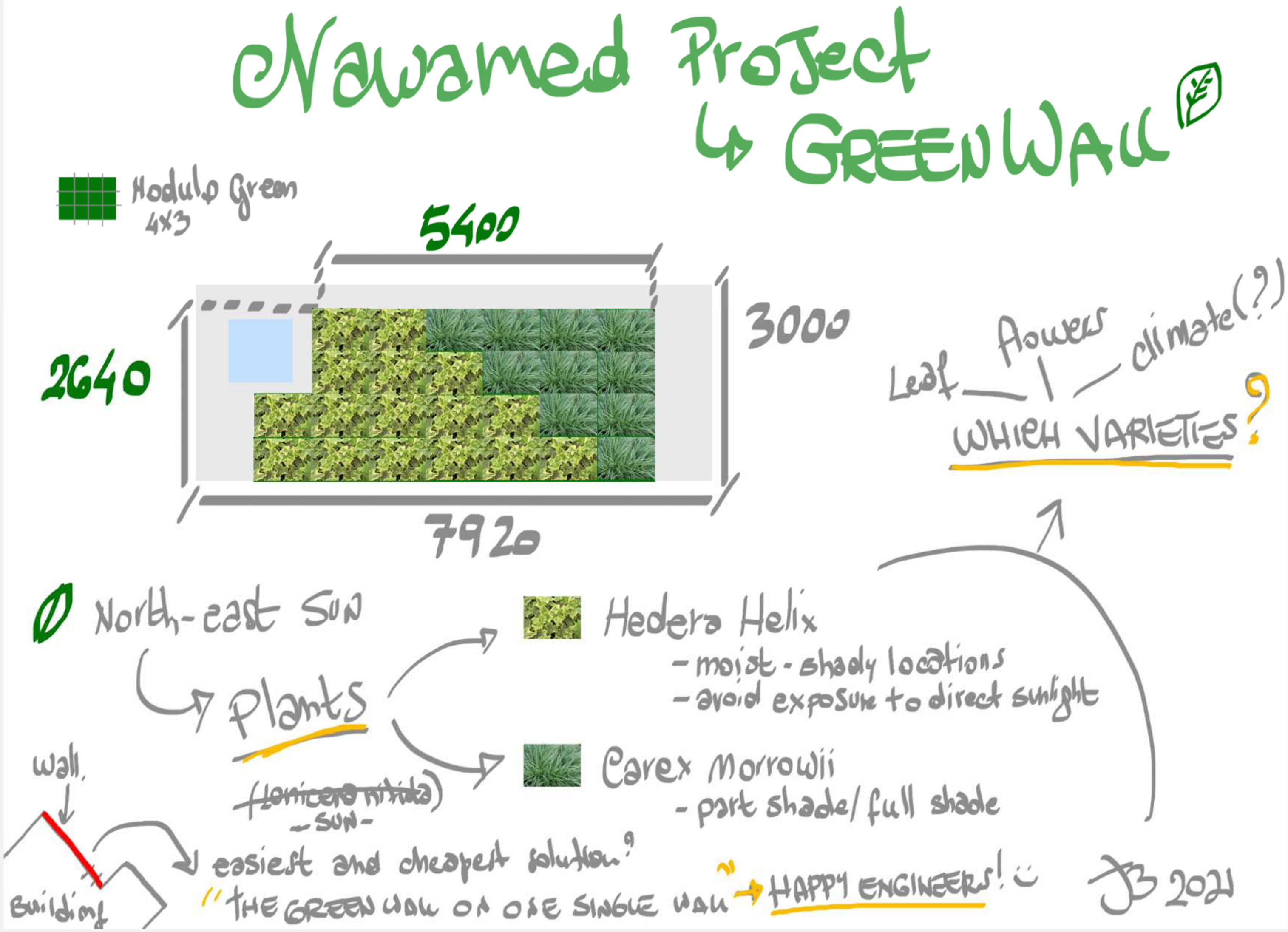
Greywater Tank



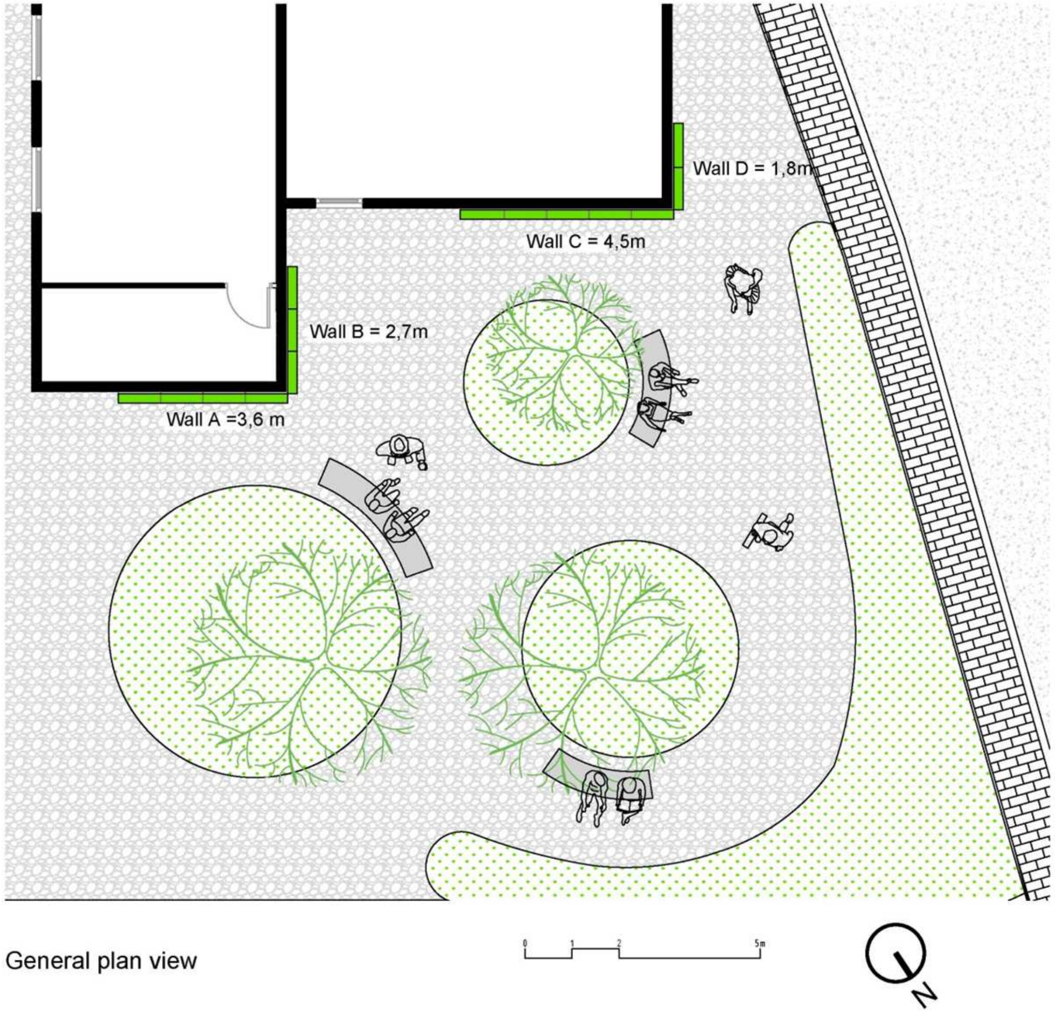
SWM House

4 Toilets

Case Study – Conceptual design

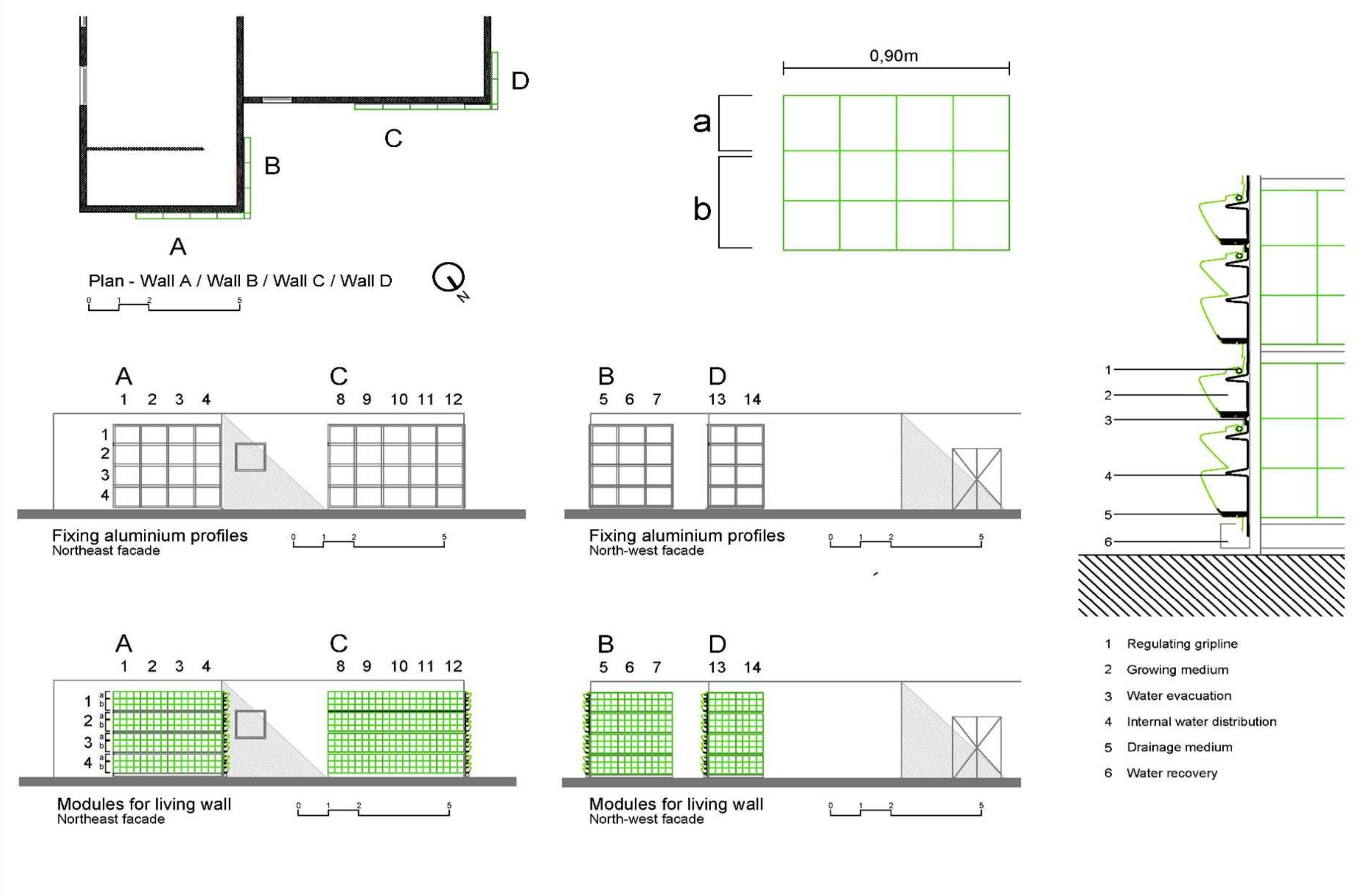


Case Study – Final results

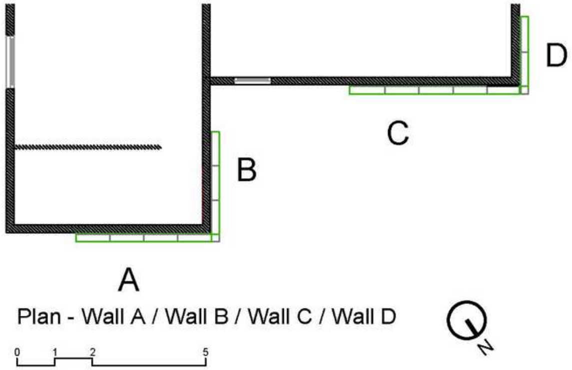


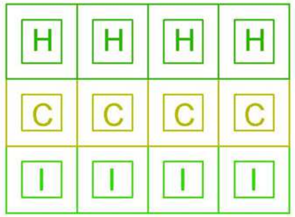
General plan view

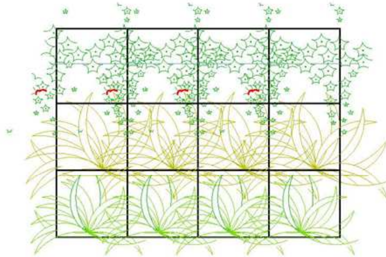
Case Study – Final results



Case Study – Final results







Iris germanica

Hedera helix

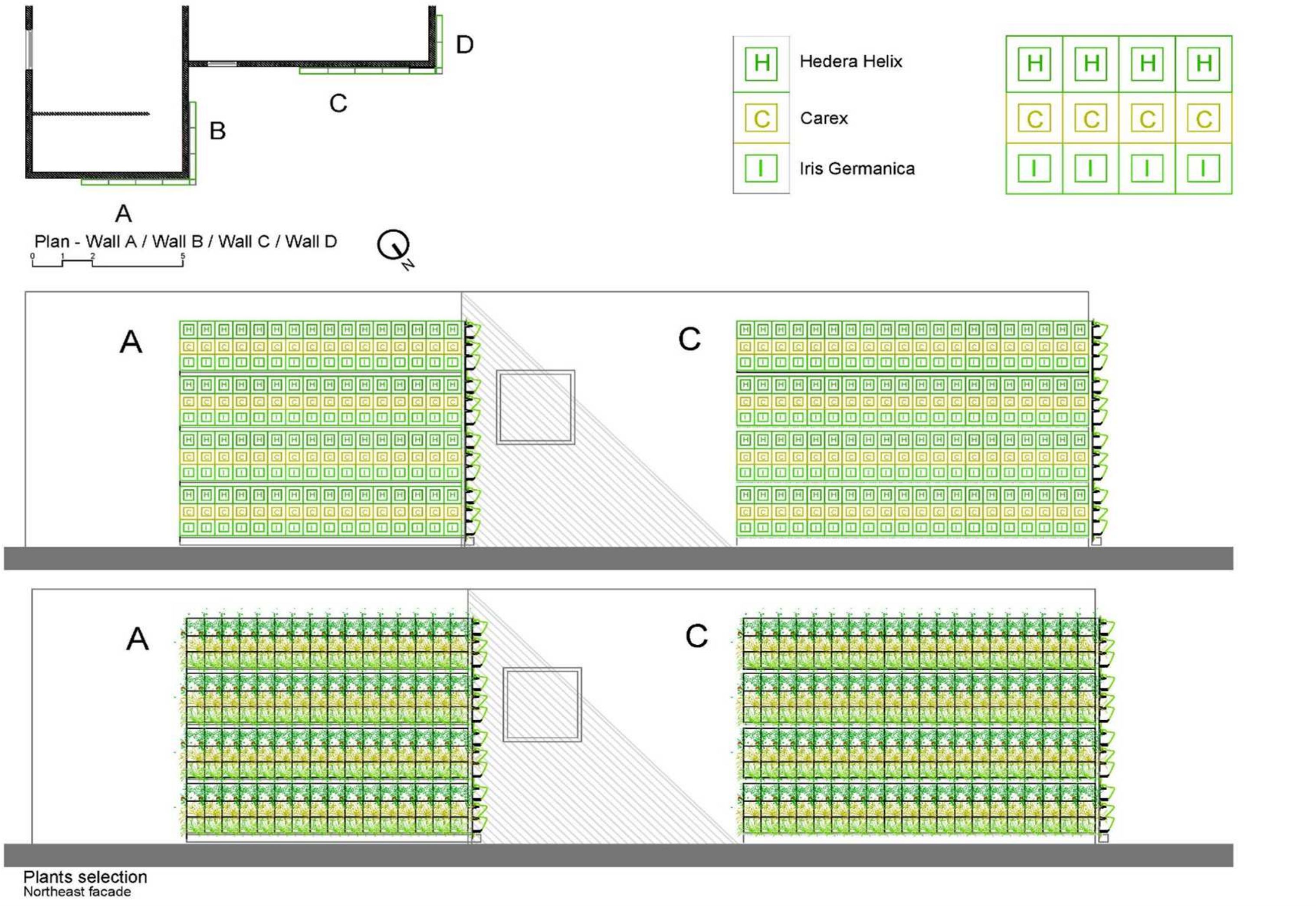
Carex Morrowii

Carex coman bronze

Carex flacca 'Blue Zinger'

Pant selection

Case Study – Final results



CW for greywater: **NAWAMED**

NAWAMED

NAWAMED pilot 1
JORDAN

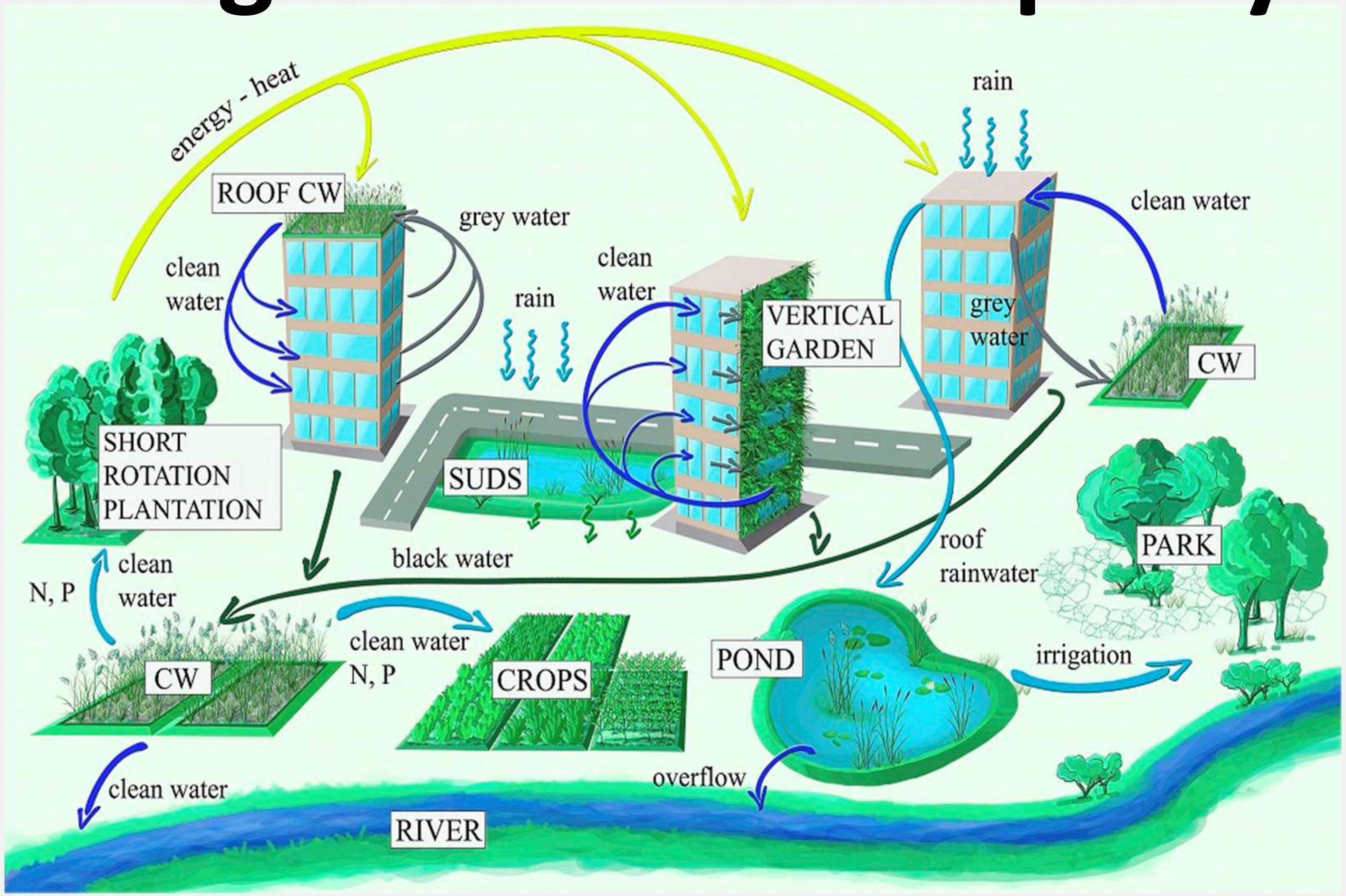
University of Jordan site Al-Zahra'a building

Information on the building
- full occupancy of the dormitory (in non-covid time) is around 300 students
- during the year the dormitory is occupied for 9-10 months

PILOT TECHNOLOGIES

- **Green facades** around building walls and toilet blocks - some 85 linear meters and a trench in the ground 50/60 cm width. **TREATED VOLUME: 4,5 mq/day that can be directly re-used in the toilets.**
- **Roof wetland** 10 square meters on the building roof. **TREATED VOLUME: 1,5 mq/day that can be directly re-used in the toilets.**
- **Green wall** anchored modules at the main entrance of the building. **TREATED VOLUME: 0,5 mq/day that can be directly re-used in the toilets.**

Building this future is up to you !



***Nature-based –solutions (NBS)* for sustainable water management integrated in a circular economy approach**

"a proficient lecture is not filling up a bucket, it's lighting a fire"

thanks for your attention !!!

Den Aardkloot van water ontbloot, na twee zyden aante fien.

contacts: fmasi@iridra.com

GLOBAL WETLAND TECHNOLOGY