11-12 FEBRUARY 2025

RABAT, MOROCCO

Institut Agronomique et Vétérinaire Hassan II

BONEX

SURE NEXUS

WEFE NEXUS INTERNATIONAL CONFERENCE

EXPLORING AND BRIDGING NEXUS FOR A SUSTAINABLE FUTURE

PRIMA IN THE MEDITERRANEAN AREA

These projects are part of the PRIMA programme supported by the European Union.

WEFE NEXUS INTERNATIONAL CONFERENCE

Day 2 – 12th February 2025

PILLAR 3: WEFE NEXUS SOLUTIONS

TOOLS AND DECISION SUPPORT SYSTEMS TO SUPPORT WEFE NEXUS IMPLEMENTATION & GOVERNANCE

REWEF Nexus Assessment Tool

Dr Johannes Hunink
Water and Climate expert
FutureWater

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EXPLORING AND BRIDGING NEXUS FOR A SUSTAINABLE FUTURE

Bridging the Gap in WEFe Nexus Assessment

RE WEFe

Johannes Hunink (j.hunink@futurewater.es)

FutureWater

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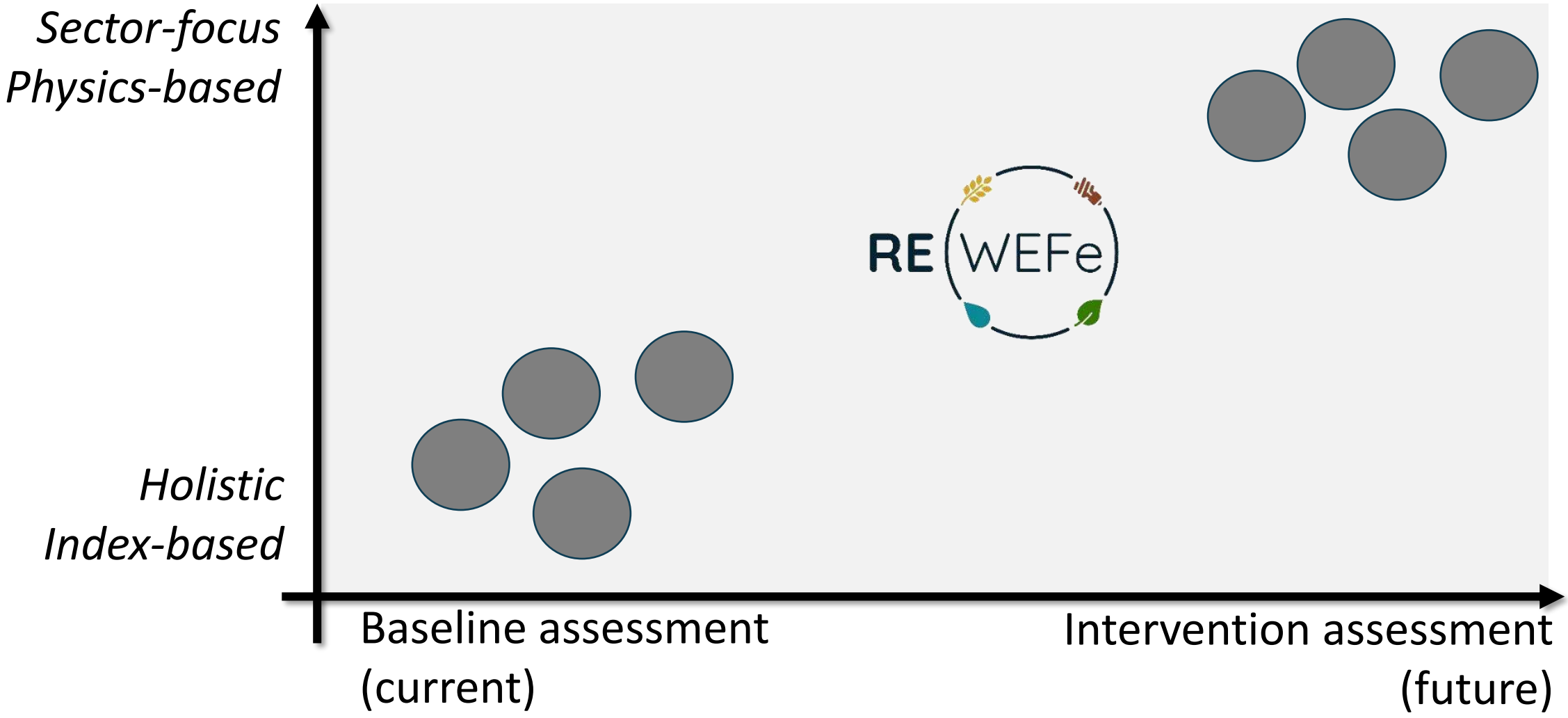
Many WEFe Nexus Tools available, but…



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The requirements / aim of the tool:

BONEX
Boosting Nexus Framework Implementation in the Mediterranean

- **Baseline assessment**
  - analyze the status of WEFe nexus in a particular region of interest
- **Intervention assessment**
  - allow for scenario analysis to analyze the potential impacts of an intervention in the region
- **Modeled linkages between the WEFe sectors**
  - Allow for scenario analysis; and allow to identify the synergies and trade-offs
- **Simple interface;** also accessible for non-expert users

Links with other BONEX tools

Causal Loop Diagram:
Establish nexus unit, select key processes

Cost Benefit Analysis:
Environmental benefits and costs

Nexus Bridging Plans

Ecosystem Services Assessment:
Offers realistic values for monetary parameters and ensure key ecosystem services are included

As input for stakeholder workshops:
Stakeholder consultations and building a case for BONEX interventions

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Tool: Concept and Development

REWEFe: Rapid Evaluation of Water Energy Food Ecosystem nexus

(Quantifying the inter- and intra-linkages among the four WEFe domains)

- Based on existing approaches
  - FAO “Follow the Water” concept
  - FAO “REWAS” (REal Water savings in Agricultural Systems)
  - FAO Food Balance Sheets

- Key underlying principle is the mass **balance**:

Produced + Import = Consumed + Output

- Scenario based (what if?)
- For more advanced sector analysis and optimization:
  - WEAP, LEAP, AquaCrop, GAMS, …

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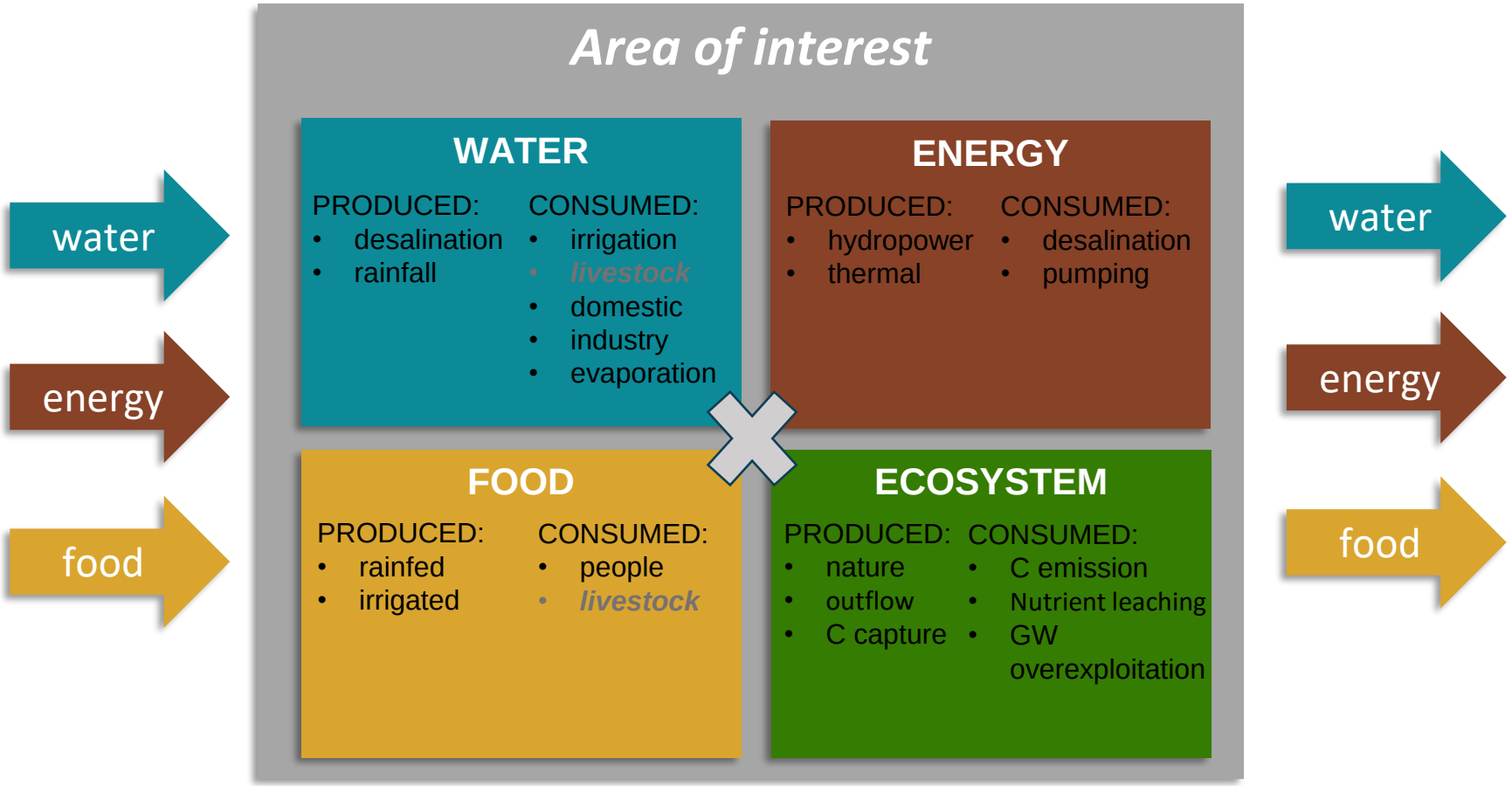
Produced vs Consumed and Import vs Export

Changes in the four domains are linked with physics-based equations



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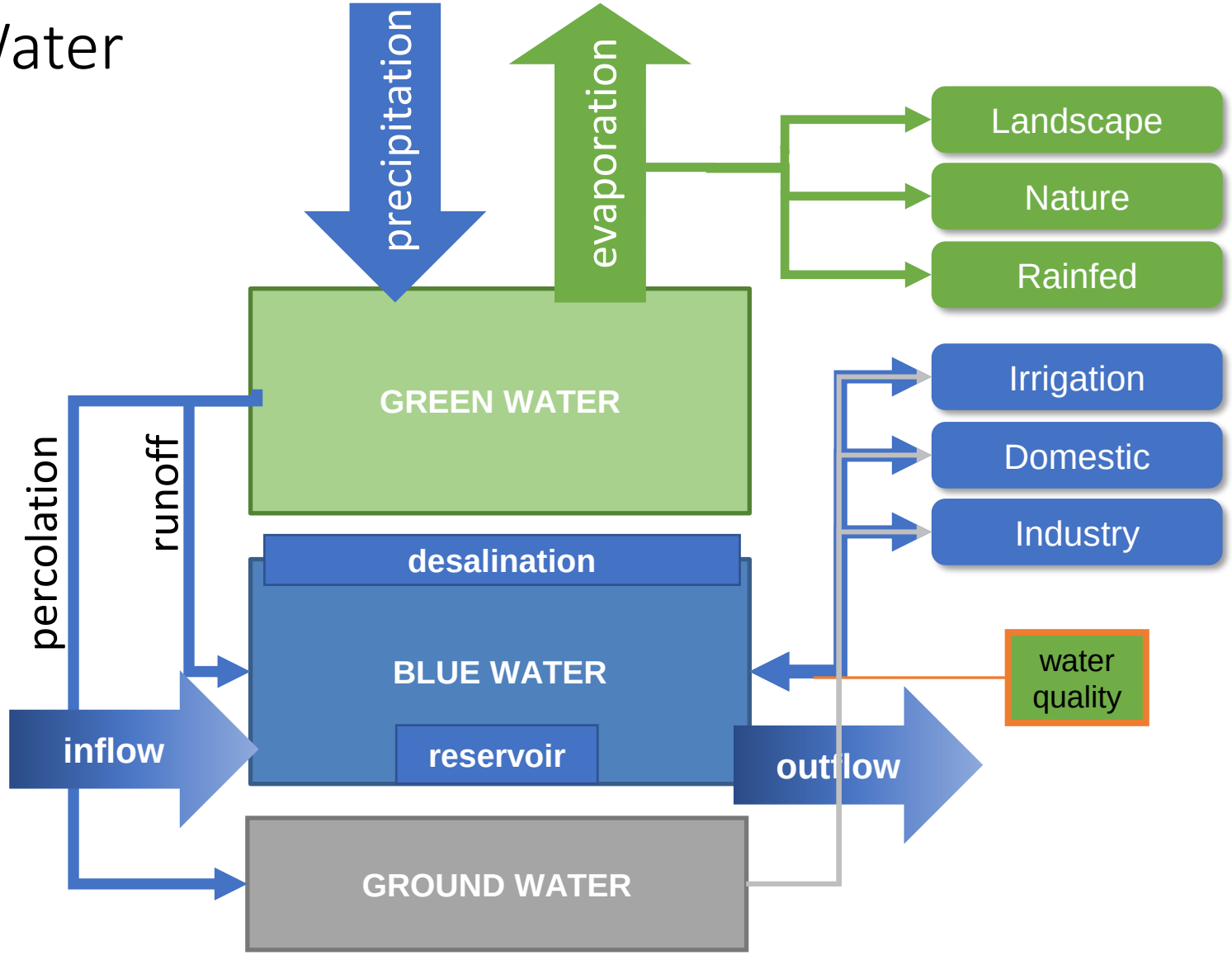
REWEFe: Water



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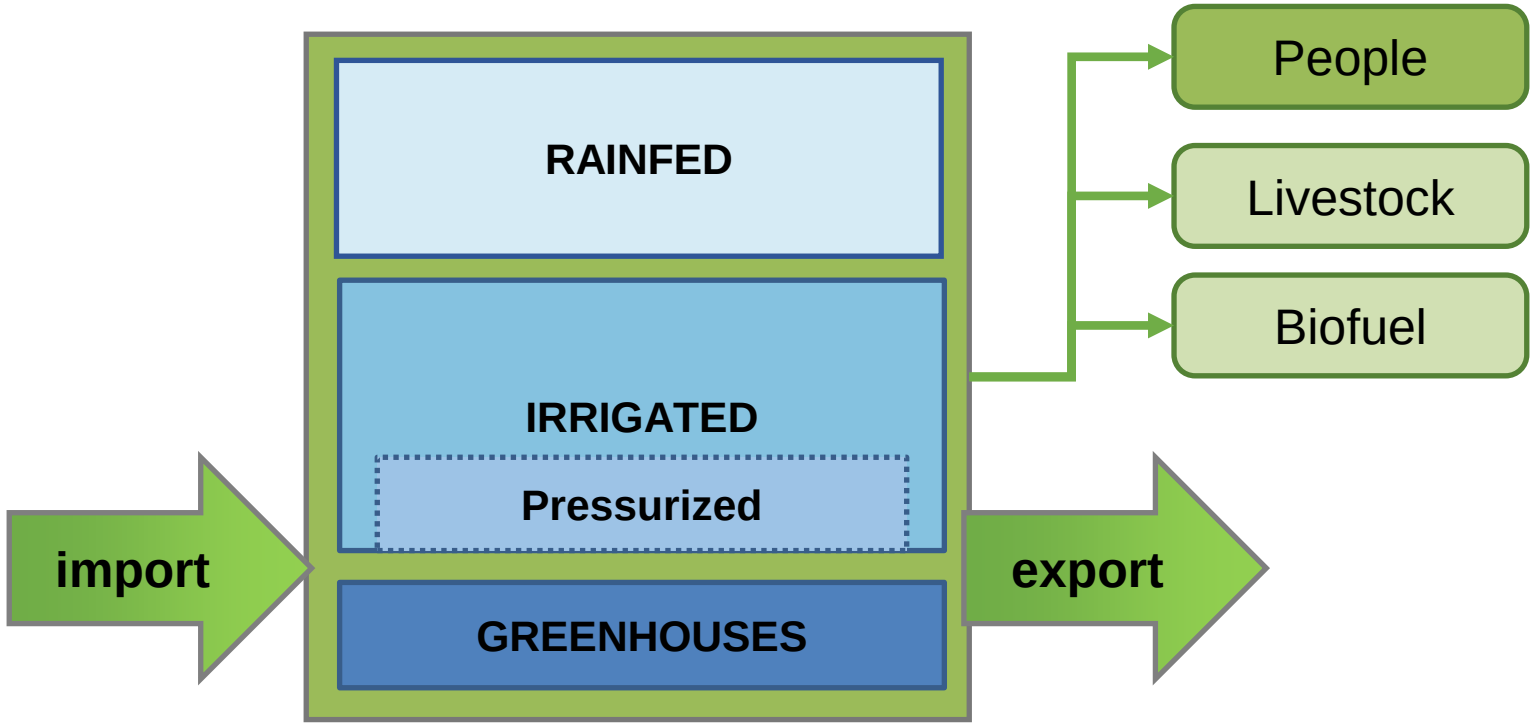
REWEFe: Food



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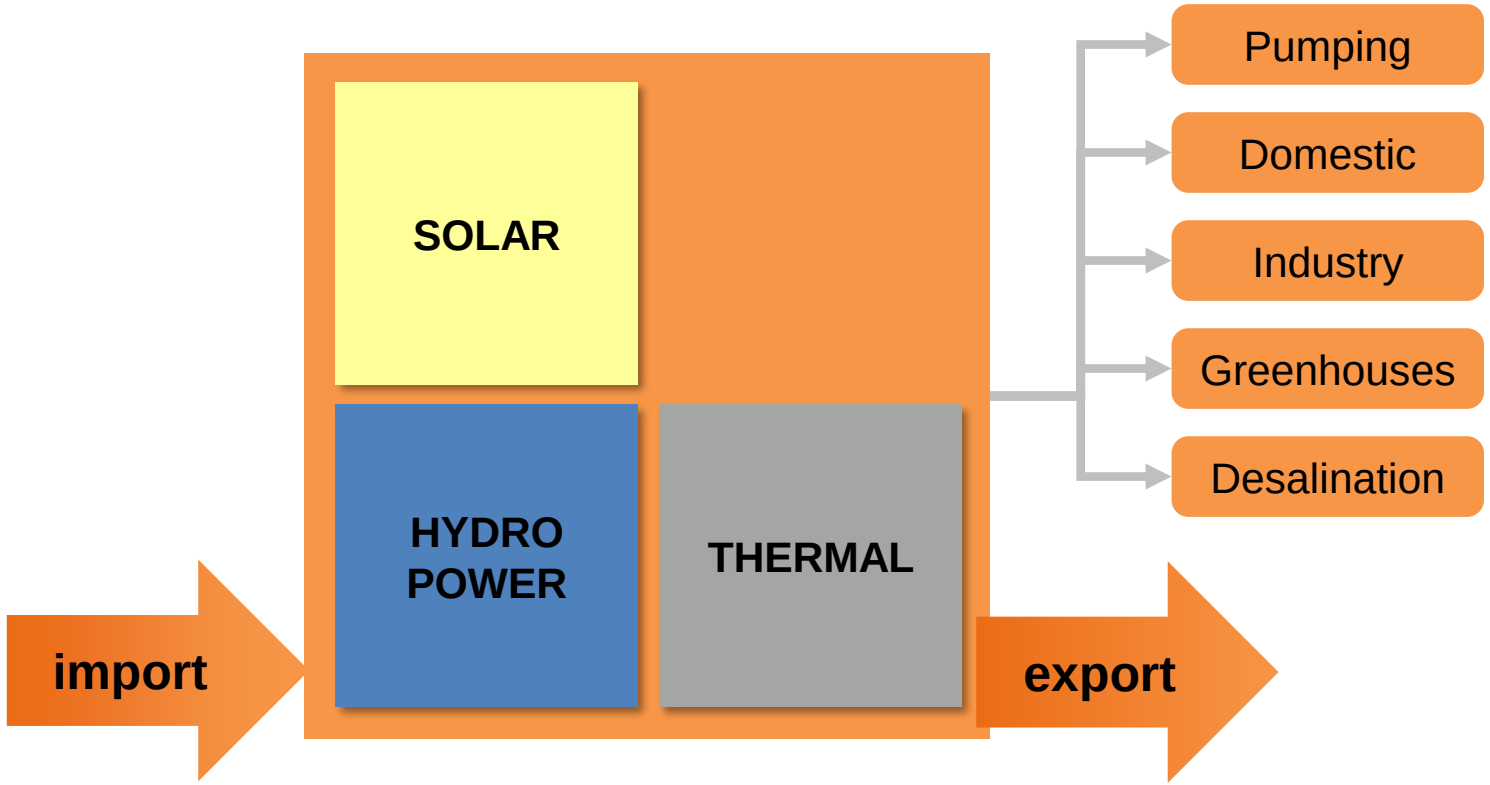
REWEFe: Energy



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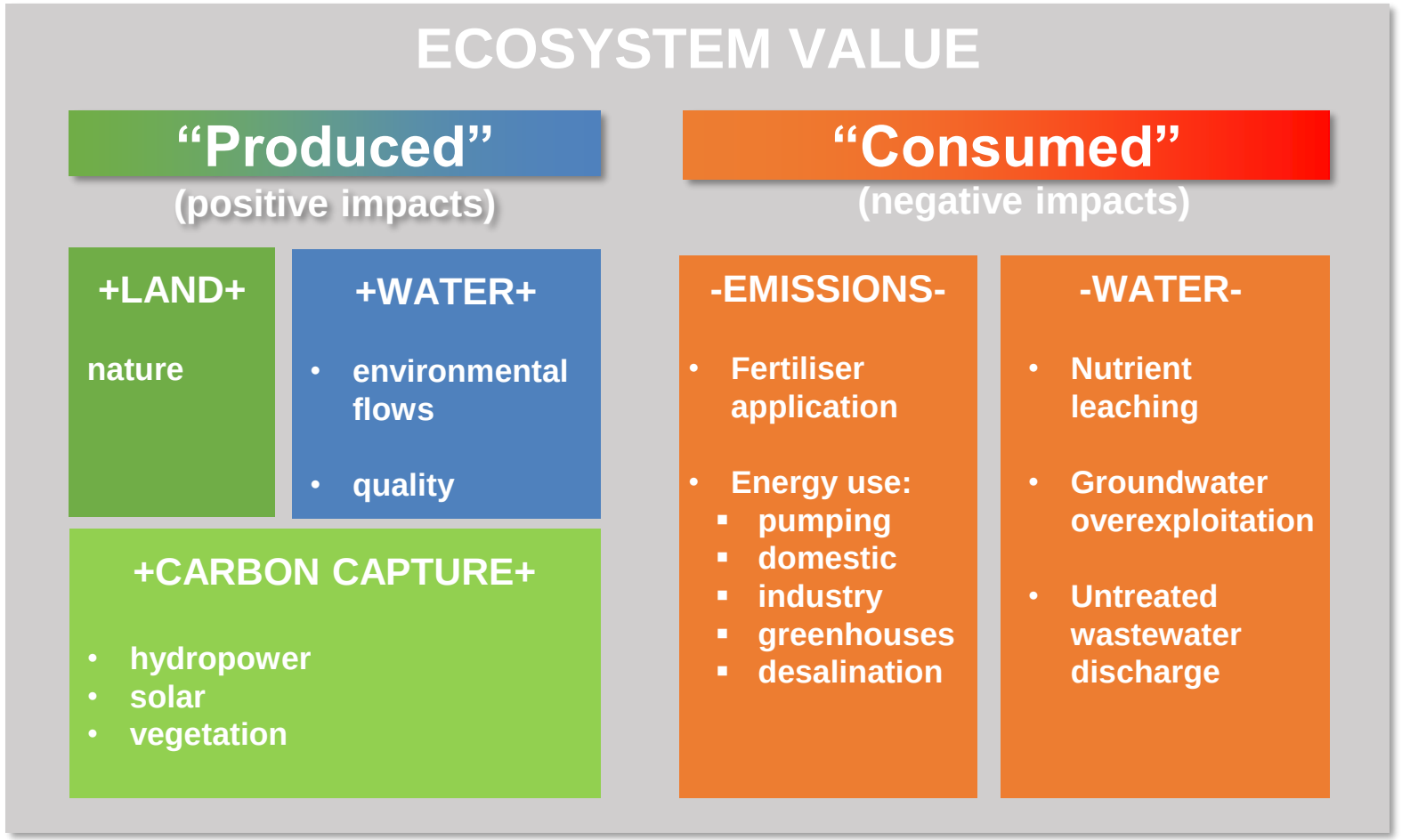
REWEFe: Ecosystem (value)



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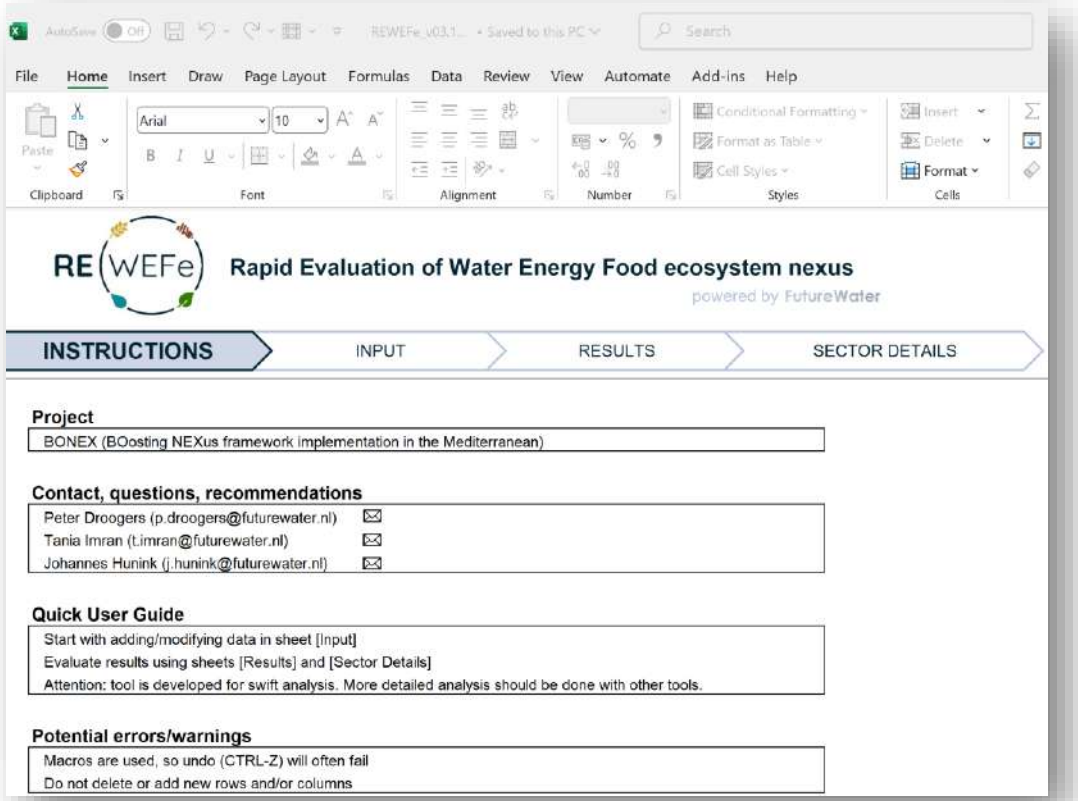
Instructions tab



RE WEFe Rapid Evaluation of Water Energy Food ecosystem nexus

powered by FutureWater

INSTRUCTIONS | INPUT | RESULTS | SECTOR DETAILS

Project

BONEX (BOosting NEXus framework implementation in the Mediterranean)

Contact, questions, recommendations

Peter Droogers (p.droogers@futurewater.nl)
Tania Imran (t.imran@futurewater.nl)
Johannes Hunink (j.hunink@futurewater.nl)

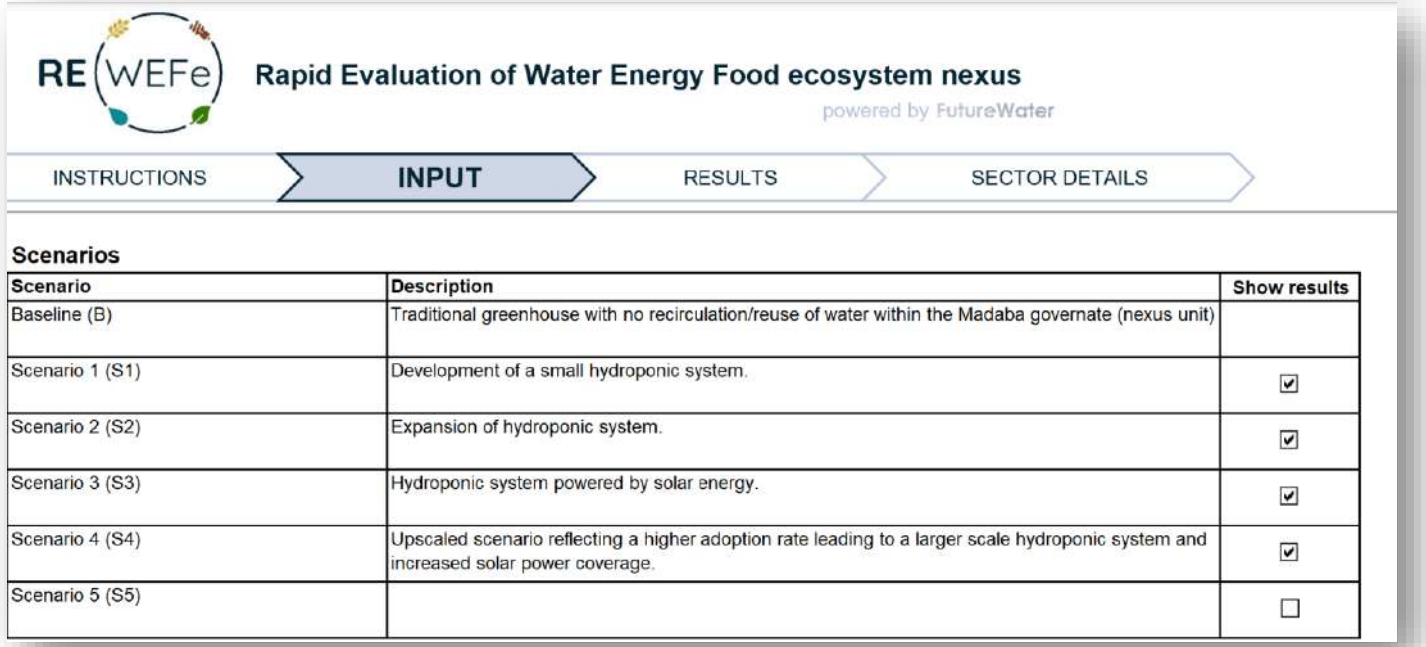
Quick User Guide

Start with adding/modifying data in sheet [Input]
Evaluate results using sheets [Results] and [Sector Details]
Attention: tool is developed for swift analysis. More detailed analysis should be done with other tools.

Potential errors/warnings

Macros are used, so undo (CTRL-Z) will often fail
Do not delete or add new rows and/or columns

Input tab



RE WEFe Rapid Evaluation of Water Energy Food ecosystem nexus

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INSTRUCTIONS | INPUT | RESULTS | SECTOR DETAILS

Scenarios

Scenario	Description	Show results
Baseline (B)	Traditional greenhouse with no recirculation/reuse of water within the Madaba governate (nexus unit)	
Scenario 1 (S1)	Development of a small hydroponic system.	☑
Scenario 2 (S2)	Expansion of hydroponic system.	☑
Scenario 3 (S3)	Hydroponic system powered by solar energy.	☑
Scenario 4 (S4)	Upscaled scenario reflecting a higher adoption rate leading to a larger scale hydroponic system and increased solar power coverage.	☑
Scenario 5 (S5)		☐

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RE WEFe **Rapid Evaluation of Water Ener**

INSTRUCTIONS | **INPUT**

Scenario 5 (S5)		

Land use

		B
Total	(km2)	950
Nature	(%)	25%
Other	(%)	52%
Rainfed	(%)	0%
Irrigated	(%)	23%
Irrigated pressurized (% of irrigated)	(%)	75%
Greenhouse area	(%)	1%
Total (check)	*(%)*	*100%*

Population

Total	(cap)	228,200
Domestic water demand	(m3/p/y)	28
Return flow urban	(%)	67%
Food demand	(kCal/p/d)	2,776
Energy demand urban	(kWh/p/y)	1,701

Industry

Units	(-)	59
Industrial water demand	(m3/u/d)	19
Return flow industry	(%)	75%
Energy demand industry	(MWh/u/y)	2

WATER

Precipitation	(mm/y)	243
ETpot	(mm/y)	632
Irrigation requirement	(mm/y)	321
Greenhouse requirement	(mm/y)	241
Runoff fraction	(-)	0.3
Recharge fraction	(-)	0.5
Reclaimed fraction	(%)	95%
Pumping capacity	(MCM/y)	
Pumping depth	(m)	
Pump efficiency	(-)	
Desalination amount	(MCM/y)	
Inflow	(MCM/y)	10

ENERGY

Pressurized irrigation (consumption)	(MWh/ha)	1.0
Greenhouses (consumption)	(kWh/m2)	55.6
Reservoir storage capacity	(MCM)	
Hydraulic head	(m)	
Hydropower capacity factor (efficiency)	(-)	
Hydropower running fraction	(-)	
Desalination energy consumption	(MWh/MCM)	
Thermal plants production	(GWh/y)	
Total solar panel surface area	(m2)	0
Photovoltaic energy yield	(kWh/m2/y)	0

FOOD

Rainfed agriculture	(kg/ha)	160
Irrigated agriculture, potential	(kg/ha)	2,415
Greenhouses, potential	(kg/ha)	9,961
Nutrient loading reclaimed water	(%)	50%
Nutrient loading by fertilizer	(%)	100%
Nutrient uptake fraction	(%)	50%
Caloric value	(kCal/kg)	1,610

ECOSYSTEM

Nature valuation	(€/km2/y)	400
Water outflow (environmental flows)	(€/m3)	0.5
Overexploitation pumping cost	(€/m3)	0.4
Nutrient excess, costs	(€/m3)	0.4
CO2e per fertilized area	(ton CO2e/ha)	0.5
CO2e per MWh	(ton CO2e)	0.4
CO2e price	(€/ton)	80

BONEX SURE NEXUS

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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RE WEFe **Rapid Evaluation of Water Energy Food ecosystem nexus**

powered by FutureWater

INSTRUCTIONS | INPUT | **RESULTS** | SECTOR DETAILS

☑ **Show tables**

	WATER (MCM/y)					ENERGY (GWh/y)					FOOD (Mkg/y)					ECOSYSTEM (mEUR/y)				
	B	S1	S2	S3	S4	B	S1	S2	S3	S4	B	S1	S2	S3	S4	B	S1	S2	S3	S4
Results																				
Produced	125.00	125.00	125.00	125.00	125.00	0.00	0.00	0.00	0.01	0.03	53.54	53.87	58.40	58.40	71.97	1.07	1.21	4.04	4.04	5.70
Consumed	132.88	132.59	126.82	126.82	123.44	668.16	470.33	536.35	536.35	734.43	143.64	143.64	143.64	143.64	143.64	23.01	16.30	18.38	18.38	24.61
Import	10.00	10.00	10.00	10.00	10.00	668.16	470.33	536.35	536.35	734.40	90.10	89.76	85.24	85.24	71.67					
Export	2.12	2.40	8.18	8.18	11.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
Balance (check)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*					
Change compared to baseline																				
Produced		0.00	0.00	0.00	0.00		0.00	0.00	0.01	0.03		0.34	4.86	4.86	18.43		0.14	2.97	2.97	4.62
Consumed		-0.29	-6.06	-6.06	-9.43		-197.84	-131.81	-131.81	66.26		0.00	0.00	0.00	0.00		-6.71	-4.64	-4.64	1.59
Import		0.00	0.00	0.00	0.00		-197.84	-131.81	-131.82	66.24		-0.34	-4.86	-4.86	-18.43					
Export		0.29	6.06	6.06	9.43		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00					
Change (%) compared to baseline																				
Produced		0%	0%	0%	0%		*Infinite*	*Infinite*	*Infinite*	*Infinite*		1%	9%	9%	34%		13%	276%	276%	430%
Consumed		0%	-5%	-5%	-7%		-30%	-20%	-20%	10%		0%	0%	0%	0%		-29%	-20%	-20%	7%
Import		0%	0%	0%	0%		-30%	-20%	-20%	10%		0%	-5%	-5%	-20%					
Export		14%	286%	286%	446%		*Infinite*	*Infinite*	*Infinite*	*Infinite*		*Infinite*	*Infinite*	*Infinite*	*Infinite*					

BONEX SURE NEXUS

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Insights from REWEFe Analysis

Application across all 7 BONEX Demonstration Pilots

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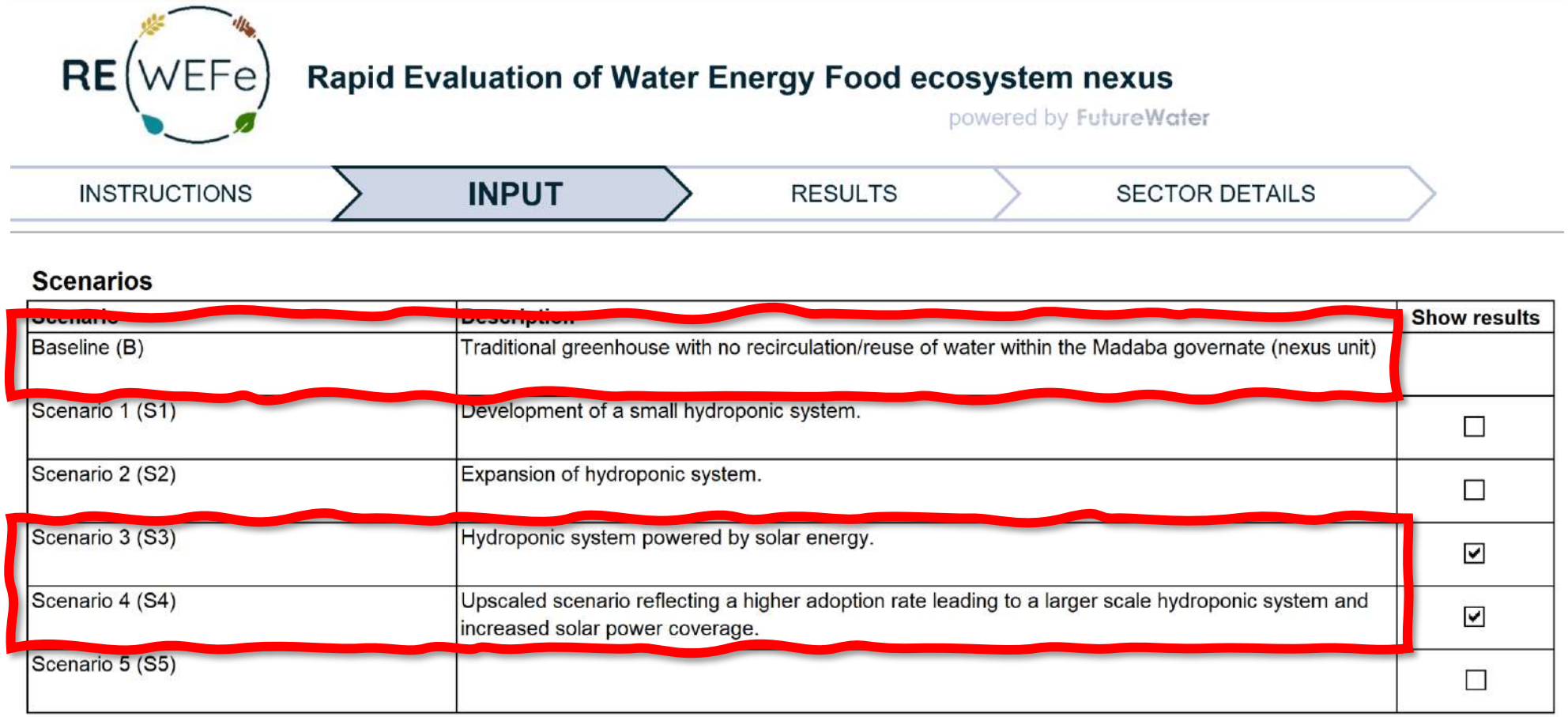
DP Jordan



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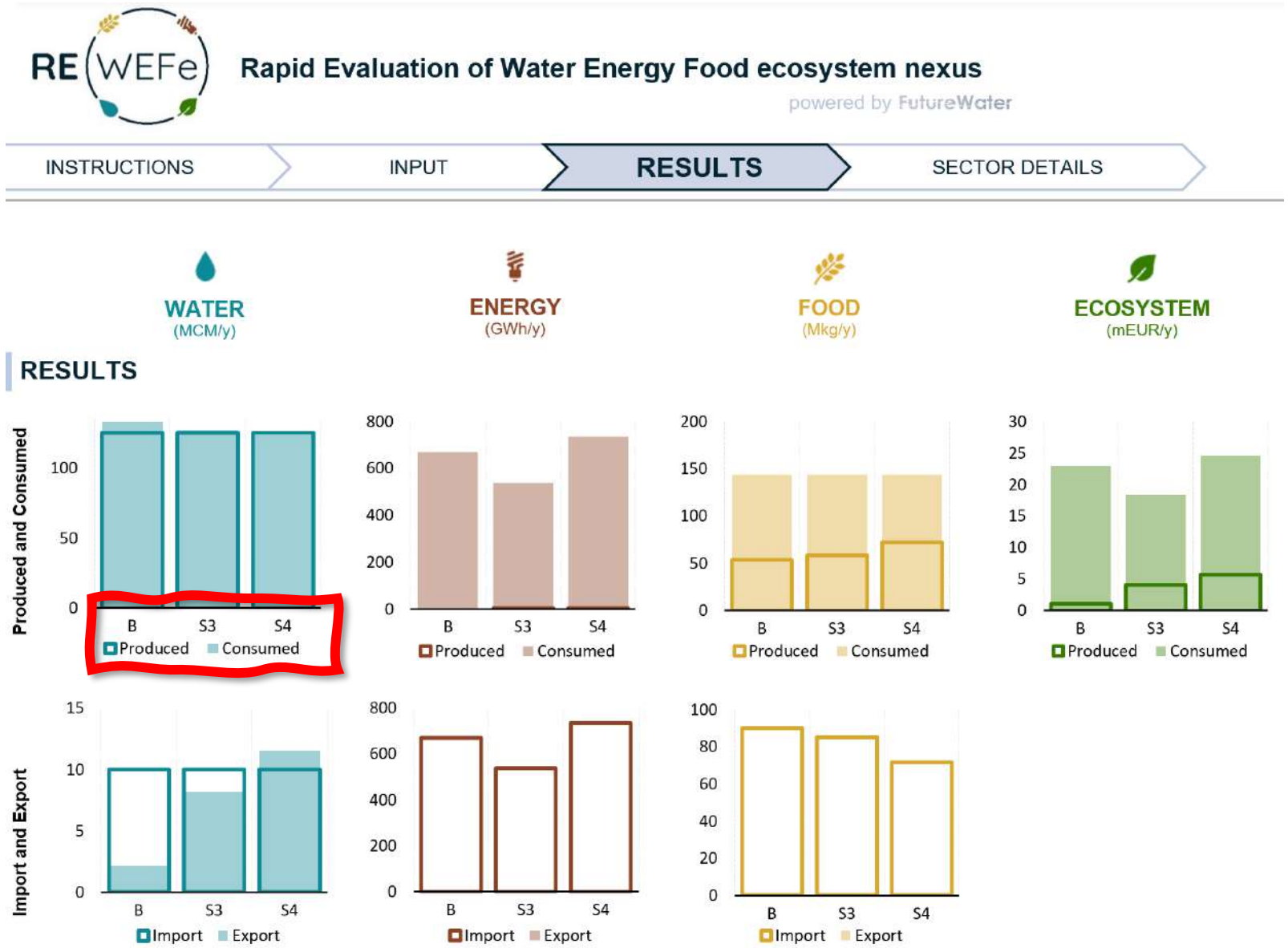
DP Jordan

B – baseline

S3: Hydroponic system powered by solar energy.

S4: Upscaled scenario reflecting a higher adoption rate leading to a larger scale hydroponic system and increased solar power coverage.



DP Jordan

B – baseline

S3: Hydroponic system powered by solar energy.

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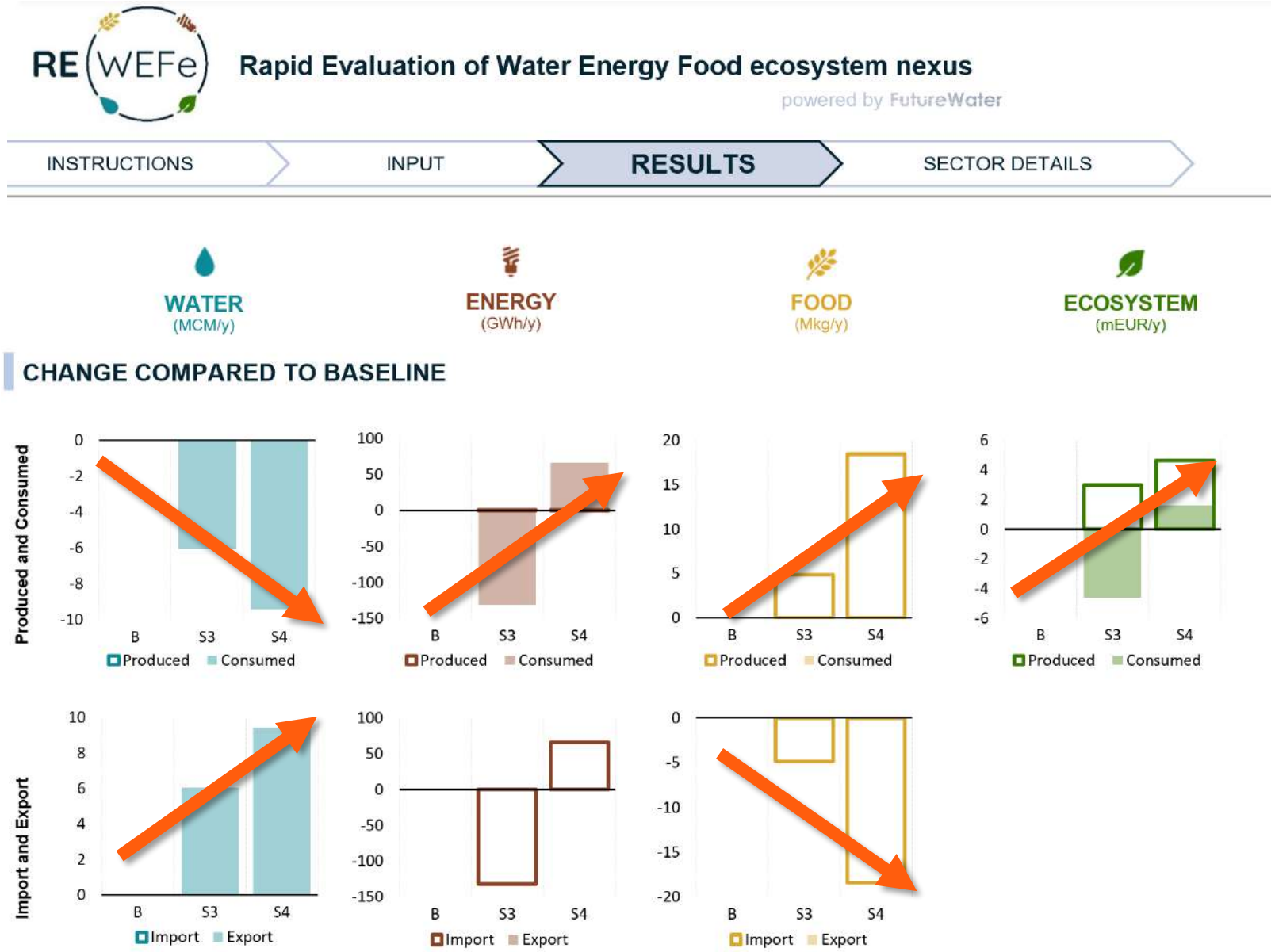

Detailed results tab, including performance indicators

RE(WEFe) Rapid Evaluation of Water Energy Food ecosystem nexus

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INSTRUCTIONS | INPUT | RESULTS | SECTOR DETAILS

WATER	B	S3	S4
(MCM/y)			
Produced	**125.00**	**125.00**	**125.00**
Rainfall	230.85	230.85	230.85
Desalination	0.00	0.00	0.00
Reclaimed	4.03	4.03	4.03
Groundwater Delta	109.88	109.88	109.88
Consumed	**132.88**	**126.82**	**123.44**
Evapotranspiration	56.79	56.79	56.79
Irrigation	68.61	61.75	54.89
Greenhouse	1.14	1.94	5.43
Domestic	6.33	6.33	6.33
Industry	0.00	0.00	0.00
Import / Export			
Inflow	10.00	10.00	10.00
Outflow	2.12	8.18	11.55
Change (%)			
Produced	**0%**	**0%**	**0%**
Rainfall	0%	0%	0%
Desalination	0%	0%	0%
Reclaimed	0%	0%	0%
Groundwater Delta	0%	0%	0%
Consumed	**0%**	**-5%**	**-7%**
Evapotranspiration	0%	-0%	0%
Irrigation	0%	-10%	-20%
Greenhouse	0%	+70%	+375%
Domestic	0%	0%	0%
Industry	0%	0%	0%
Import / Export			
Inflow	0%	0%	0%
Outflow	0%	+286%	+446%
Other relevant factors			
Groundwater Recharge (MCM/y)	109.88	109.88	109.88
Groundwater Pumping (MCM/y)	0.00	0.00	0.00
Green Water Shortage (MCM/y)	540.61	537.61	528.60
Blue Water Shortage (MCM/y)	0.00	0.00	0.00
Green Water Stress (%)	90%	90%	90%
Blue Water Stress (%)	0%	0%	0%

ENERGY	B	S3	S4
(GWh/y)			
Produced	**0.00**	**0.01**	**0.03**
Hydropower	0.00	0.00	0.00
Thermal	0.00	0.00	0.00
Solar	0.00	0.01	0.03
Consumed	**668.16**	**536.35**	**734.43**
Desalination	0.00	0.00	0.00
Pumping	0.00	0.00	0.00
Irrigation presurized	16.03	16.03	16.03
Greenhouses	263.86	132.05	330.13
People	388.17	388.17	388.17
Industry	0.10	0.10	0.10
Import / Export			
Import	668.16	536.35	734.40
Export	0.00	0.00	0.00
Change (%)			
Produced	**0%**	**+999%**	**+999%**
Hydropower	0%	0%	0%
Thermal	0%	0%	0%
Solar	0%	+999%	+999%
Consumed	**0%**	**-20%**	**+10%**
Desalination	0%	0%	0%
Pumping	0%	0%	0%
Irrigation presurized	0%	0%	0%
Greenhouses	0%	-50%	+25%
People	0%	0%	0%
Industry	0%	0%	0%
Import / Export			
Import	0%	0%	0%
Export	0%	-20%	+10%
Other relevant factors			
Hydropower Capacity (MW)	0.00	0.00	0.00

FOOD	B	S3	S4
(Mkg/y)			
Produced	**53.54**	**58.40**	**71.97**
Rainfed	0.00	0.00	0.00
Irrigated	49.04	49.35	49.35
Greenhouses	4.49	9.05	22.62
Consumed	**143.64**	**143.64**	**143.64**
People	143.64	143.64	143.64
Livestock	0.00	0.00	0.00
Import / Export			
Import	90.10	85.24	71.67
Export	0.00	0.00	0.00
Change (%)			
Produced	**0%**	**+9%**	**+34%**
Rainfed	0%	+1%	+2%
Irrigated	0%	+1%	+1%
Greenhouses	0%	+101%	+403%
Consumed	**0%**	**0%**	**0%**
People	0%	0%	0%
Livestock	0%	0%	0%
Import / Export			
Import	0%	-5%	-20%
Export	0%	0%	0%
Other relevant factors			
Nutrient Stress (%)	25%	22%	22%
Decrease in Production (%)	-5%	-4%	-4%

ECOSYSTEM	B	S3	S4
(mEUR/y)			
Produced	**1.07**	**4.04**	**5.70**
Land	0.04	0.04	0.04
Water outflow (env)	1.04	4.01	5.66
Hydropower CO2	0.00	0.00	0.00
Solar CO2	0.00	0.00	0.00
Consumed	**23.01**	**18.38**	**24.61**
Desalination	0.00	0.00	0.00
Pumping	0.00	0.00	0.00
Greenhouses	8.23	4.12	10.30
People	12.11	12.11	12.11
Industry	0.00	0.00	0.00
Irrigation (pressure)	0.50	0.50	0.50
Fertilizer use	0.94	0.77	0.82
Waste water (untreated)	0.08	0.08	0.08
Nutrient leaching	1.15	0.79	0.79
Groundwater overexploitation	0.00	0.00	0.00
Change (%)			
Produced	**0%**	**+276%**	**+430%**
Land	0%	0%	0%
Water outflow (env)	0%	+286%	+446%
Solar CO2	0%	+100%	+100%
Consumed	**0%**	**-20%**	**+7%**
Desalination	0%	0%	0%
Pumping	0%	0%	0%
Greenhouses	0%	-50%	+25%
People	0%	0%	0%
Industry	0%	0%	0%
Irrigation (pressure)	0%	0%	0%
Fertilizer use	0%	-18%	-13%
Waste water (untreated)	0%	0%	0%
Nutrient leaching	0%	-31%	-31%
Groundwater overexploitation	0%	0%	0%

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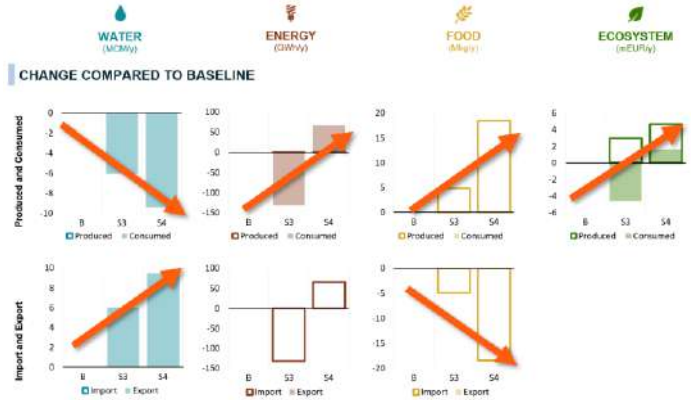
DP Jordan – headlines on synergies and trade-offs

- Energy & Food : The installation of a hydroponic system shows higher productivity and lower energy consumption as they are more energy efficient compared to traditional greenhouses. However, in the upscaled scenario, the expansion of the hydroponic system results in higher needs for energy imports.
- Ecosystem & Energy: The ecosystem benefits increase with the solar-powered hydroponic system. This is because less water is used leading to a more favorable water balance; as well as the reduction in CO2e emissions due to solar power generation. But in the upscaled scenario, this leads to higher net emissions and thus ecosystem costs
- Water & Food : Water consumption is lowered by 5-7% due to the development of a hydroponic system and reduction in conventional irrigation demands, while agricultural productivity increases
- Ecosystem & Food: Due to a higher uptake fraction as a result of nutrient monitoring and dosage adjustments, there is a certain ecosystem benefit and increase in food production.



ECOSYSTEM	B	S3	S4
(mEUR/y)			
Produced	**1.07**	**4.04**	**5.70**
Land	0.04	0.04	0.04
Water outflow (env)	1.04	4.01	5.66
Hydropower CO2	0.00	0.00	0.00
Solar CO2	0.00	0.00	0.00
Consumed	**23.01**	**18.38**	**24.61**
Desalination	0.00	0.00	0.00
Pumping	0.00	0.00	0.00
Greenhouses	8.23	4.12	10.30
People	12.11	12.11	12.11
Industry	0.00	0.00	0.00
Irrigation (pressure)	0.50	0.50	0.50
Fertilizer use	0.94	0.77	0.82
Waste water (untreated)	0.08	0.08	0.08
Nutrient leaching	1.15	0.79	0.79
Groundwater overexploitation	0.00	0.00	0.00
Change (%)			
Produced	**0%**	**+276%**	**+430%**
Land	0%	0%	0%
Water outflow (env)	0%	+286%	+446%
Solar CO2	0%	+100%	+100%
Consumed	**0%**	**-20%**	**+7%**
Desalination	0%	0%	0%
Pumping	0%	0%	0%
Greenhouses	0%	-50%	+25%
People	0%	0%	0%
Industry	0%	0%	0%
Irrigation (pressure)	0%	0%	0%
Fertilizer use	0%	-18%	-13%
Waste water (untreated)	0%	0%	0%
Nutrient leaching	0%	-31%	-31%
Groundwater overexploitation	0%	0%	0%

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What´s next

- BONEX:
  - NBPs
  - Support upscaling narrative
  - D3.3
- REWEFe implementation in three ongoing projects
  - FAO in SE-Asia, and MENA region
  - The Hague Academy - Tunesia
  - PEMSEA – SE-Asia
- Enhance visibility and reach:
  - Dedicated tool-page. Tool available for download and for free on request.
  - FutureWater Academy

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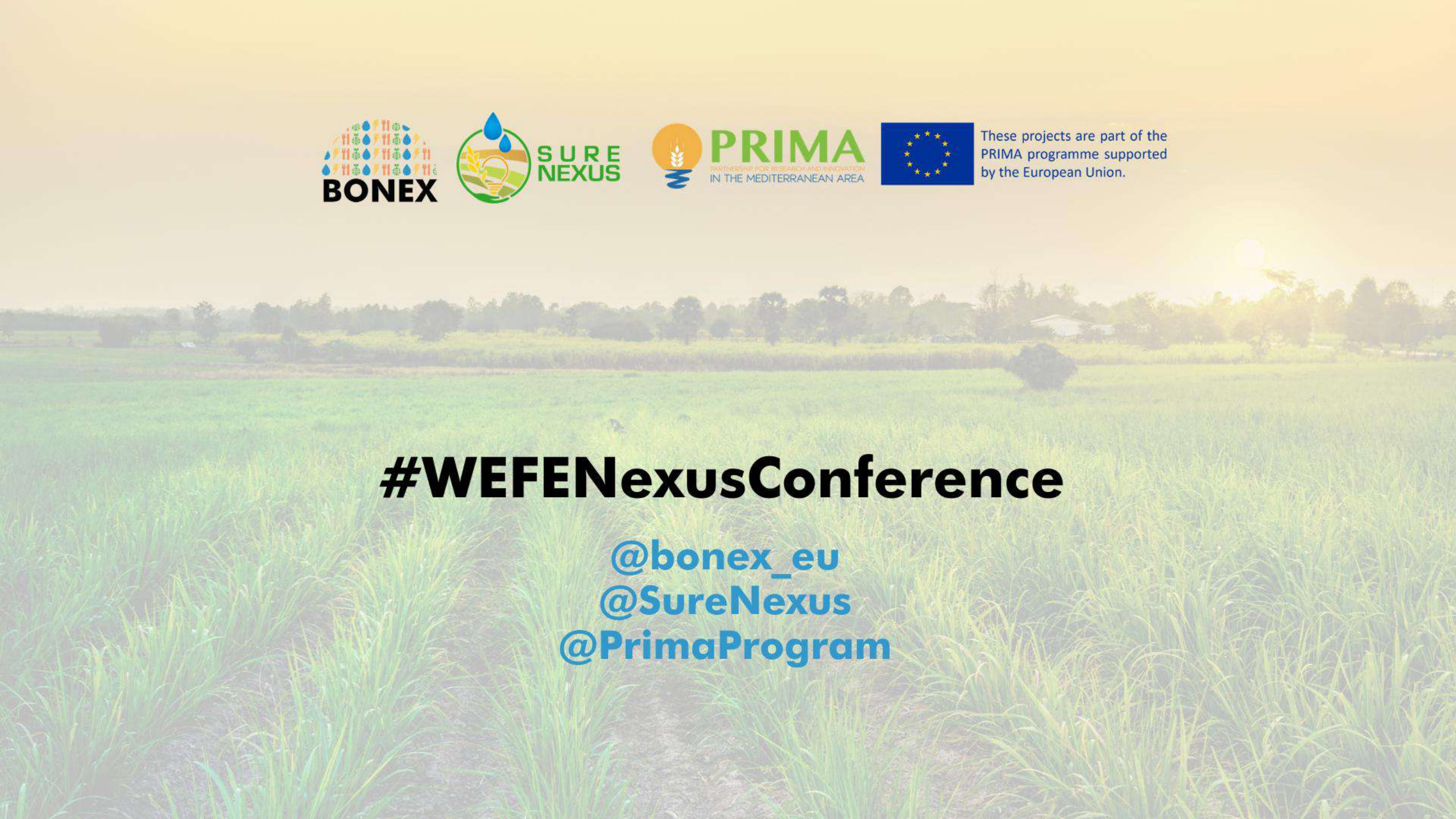
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