Food and Agriculture Organization of the United Nations

WASAG

The Global Framework on Water Scarcity in Agriculture

Saline agriculture: Scaling up opportunities and challenges

Webinar, Tuesday 26th May 2020

Speakers:

Dionysia-Angeliki Lyra

ICBA
AGRICULTURE FOR TOMORROW

Arjen de Vos

The Salt Doctors

Andrés Parra González

CEBAS
CENTRO DE EDAFOLOGÍA Y BIOLOGÍA APLICADA DEL SEGURA

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Structure of the presentation

1) Introduction to the topic

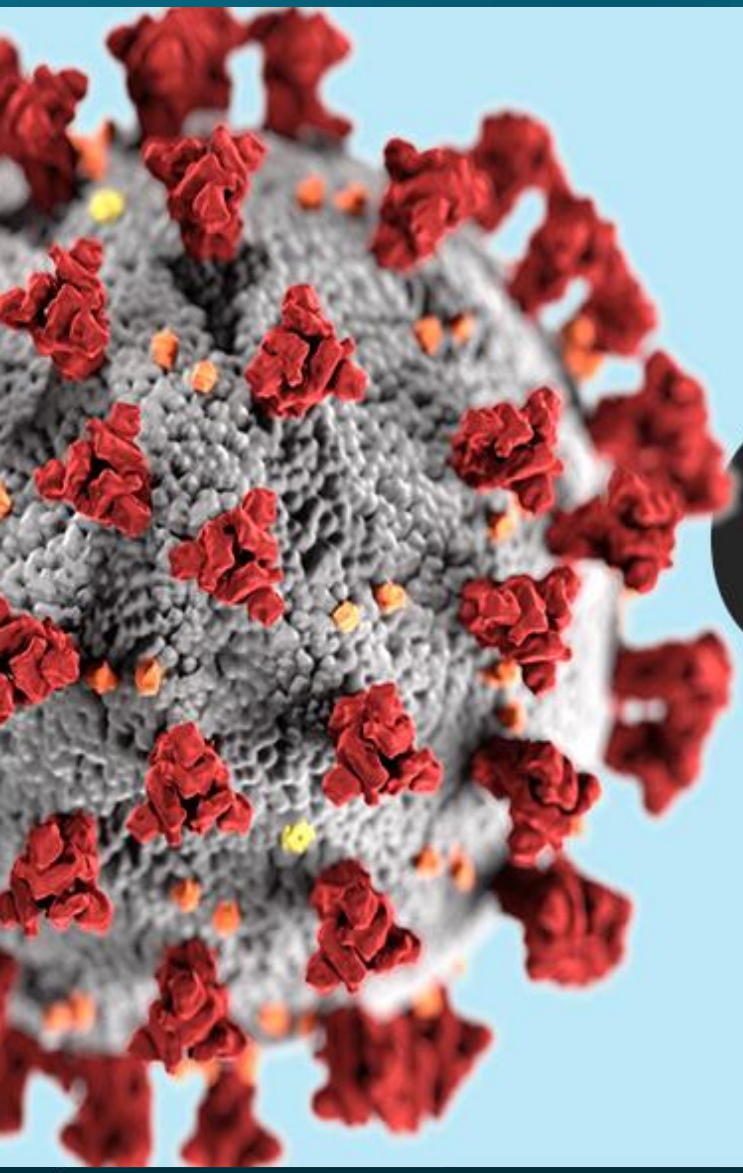
2) Opportunities for cultivation of conventional vegetable crops under saline conditions

3) Projects on Halophytes value chains in MENA region

4) Implementation of a Decision Support Tool (DST) under saline conditions. A showcase of the Mediterranean Region

5) Conclusions

1) Introduction: Vexing challenges

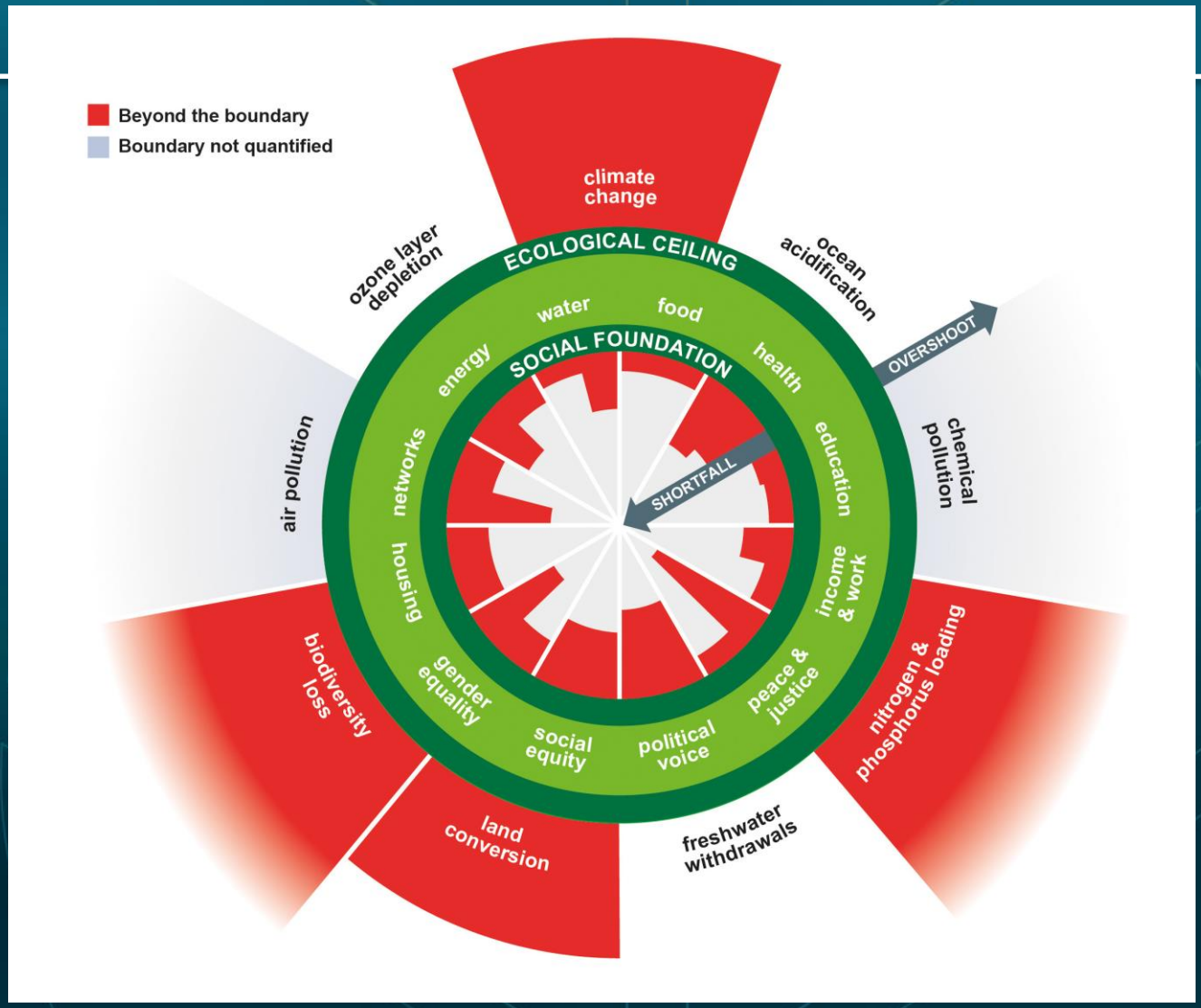


COVID-19

CORONAVIRUS PANDEMIC

.....lockdowns pushed focus on local food production

Doughnut Economics theory by Kate Raworth



https://www.weforum.org/agenda/2020/05/doughnut-model-amsterdam-coronavirus-recovery/

Why Saline Agriculture?

- ✓ Releases pressure on good quality water and land resources
- ✓ Utilizes wastelands and poor quality water resources
- ✓ Provides new sources of food, feed, biofuels, fiber
- ✓ Generates employability particularly youth and women
- ✓ Climate change mitigation: *rehabilitation of degraded lands, CO_2 sequestration*
- ✓ Climate change adaptation: improves resilience of local communities

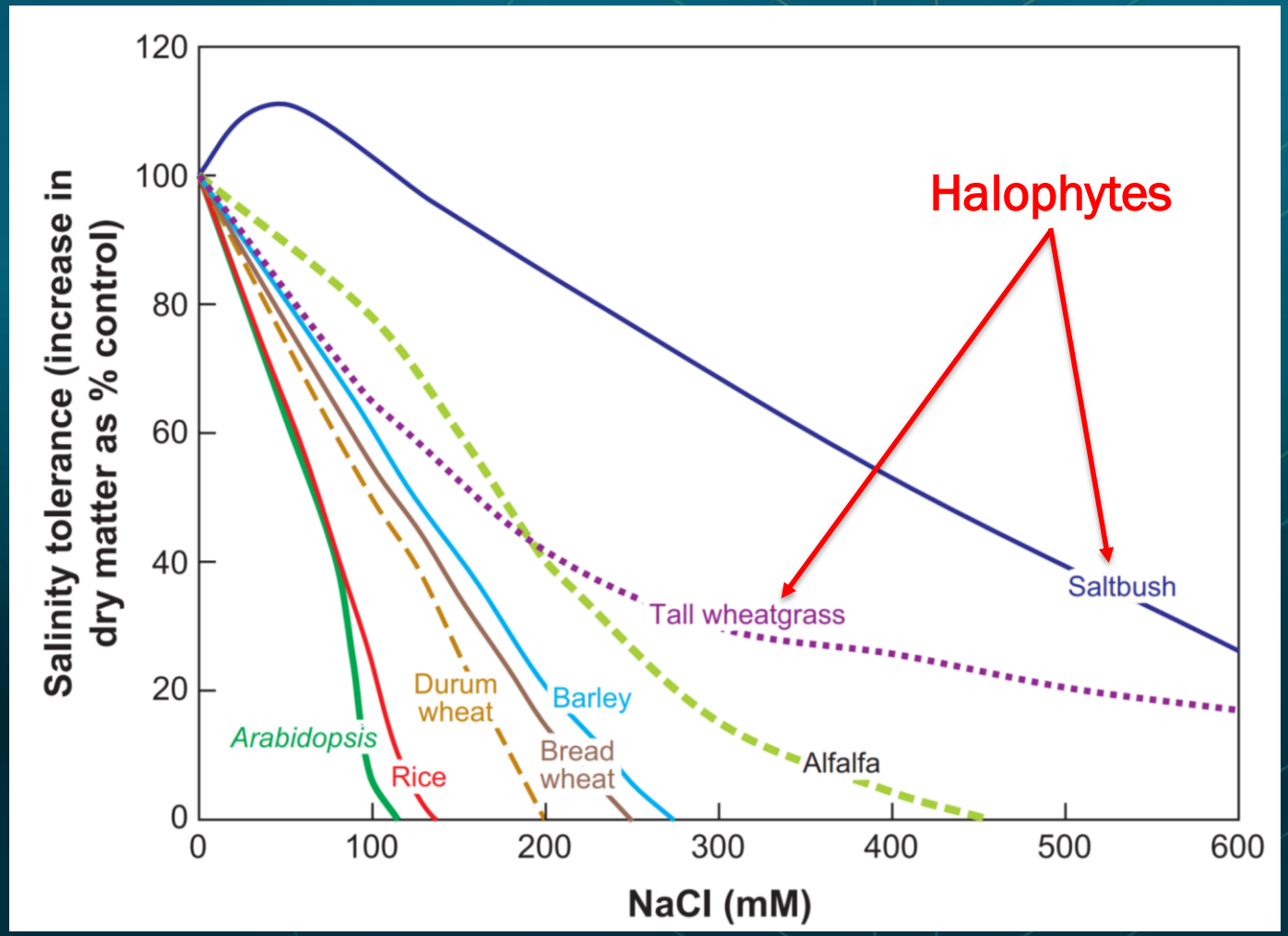
Improved food and nutrition security. Improved livelihoods.

Resources for saline agriculture implementation

- Saline water resources (brackish ground water, seawater, reject brine from desalination, drainage water, aquaculture effluents, etc.)
- Degraded soils (saline, saline-sodic, barren lands)
- Plants (salt-tolerant varieties of conventional crops, halophytes)

Crops Salinity Tolerance

Plants' dry matter increases



(Munns and Tester, Ann. Rev.PB, 2008)

Salinity increases

2) Opportunities for cultivation of conventional vegetable crops under saline conditions

The Salt Doctors – who we are -

Dr. Arjen de Vos

The Salt Doctors

E-mail address: arjen@thesaltdoctors.com

Mission: Improve crop yield under saline conditions and bring the solutions into the hands of farmers

The Salt Doctors

Service provider to develop and implement scalable solutions, work towards large-scale impact

The Salt Doctors

The Salt Doctors – who we are -

Mission: Improve crop yield under saline conditions and bring the solutions into the hands of farmers

salinity assessments

teaching

salt tolerant seeds

scalable solutions

training & capacity building

research & demonstration

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Service provider to develop and implement scalable solutions, work towards large-scale impact

The Salt Doctors

Salinity, what are we dealing with?

Around 400 million hectares of **saline soils** (potential to feed up to 2 billion people!),

the **majority is low to moderately saline** (<8-10 dS/m (EC_e)) (Wicke *et al*, 2011, Shahid *et al*., 2018, Negacz *et al*. 2020 (subm.))

The Salt Doctors

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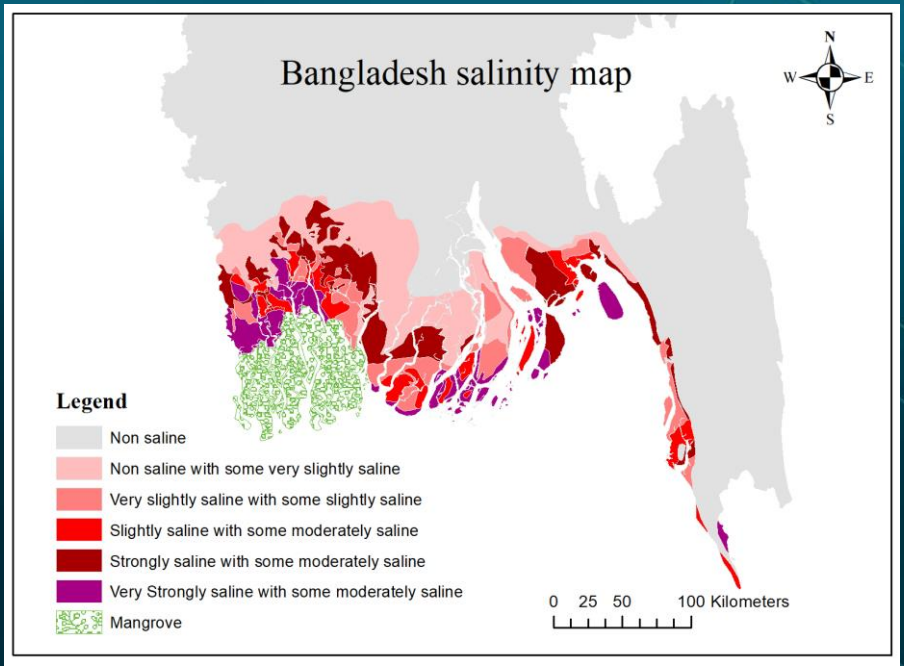

Bangladesh delta:
57% of saline soils < 8 dS/m
75% < 12 dS/m

Source: BARI 2010, modified by Negacz, 2019

Mostly moderate salinity level?

The Salt Doctors

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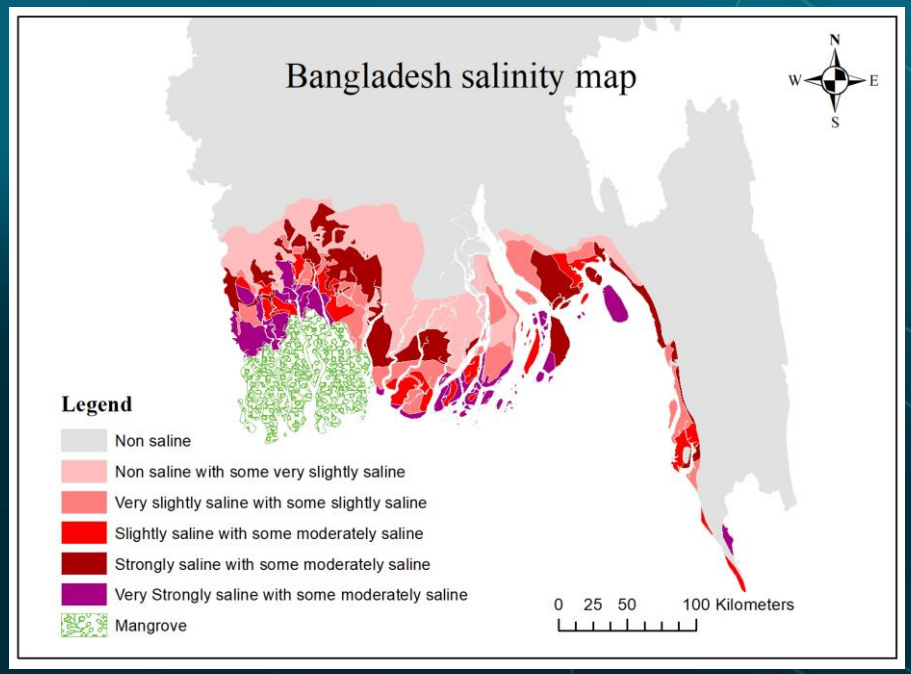

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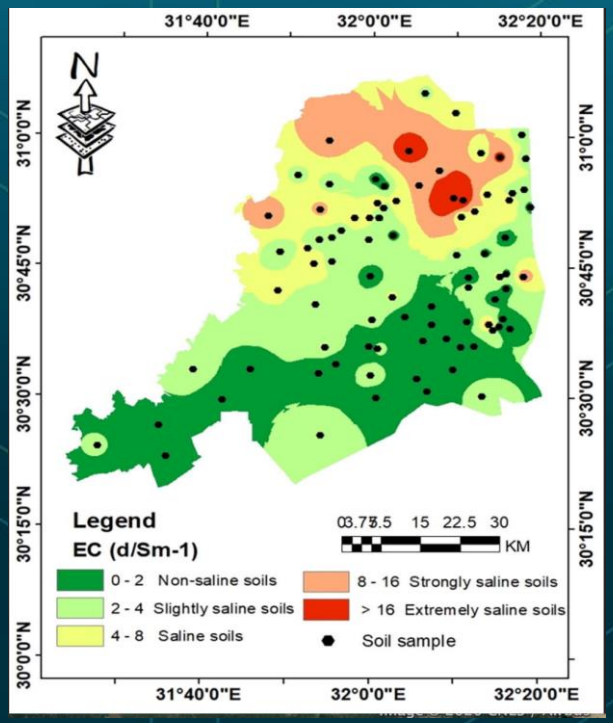

East of Egypt Nile delta: 40% of all land is saline, of which 70% < 8 dS/m

Source: Hammam & Mohamed, 2018

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Mostly moderate salinity level?

Measuring soil salinity

The Salt Doctors

Pakistan, Bangladesh, Kenya, Vietnam, Egypt, Jordan

Moderate salinity levels

The Salt Doctors

Salt tolerant varieties of conventional crops?

800 varieties of 50 different crops tested (2012-2019)

under controlled field conditions, The Netherlands

SaltFarm Texel
Tested on Texel

(moderately) tolerant, high yielding varieties found for potato, carrot, cauliflower, beetroot, among others

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More potential...

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but…saline agriculture is more than a salt tolerant crop

saline agriculture

"technical" aspects

- climatic conditions (temperature, rainfall,…)
- soil (salinity, structure, pH, fertility, tillage,…)
- water (salinity, total amount, storage,irrigation…)
- crop (salt tolerant, yield, market, cultivation,…)
- input materials (seeds, irrigation equipment,..)

socio-economic factors

- farmers (preference, level of knowledge, role model)
- training/capacity building (pilot, long term demo,…)
- entrepreneurship (market, business model,…)
- policy (rules, regulations, goverment participation,…)
- PPP (public private partnerships,…)

* crop selection
* cultivation strategy
* inputs
* knowledge & skills
* market
* scalable solutions

Cropping (techniques) + socio-economic factors

Example Capacity Building Egypt

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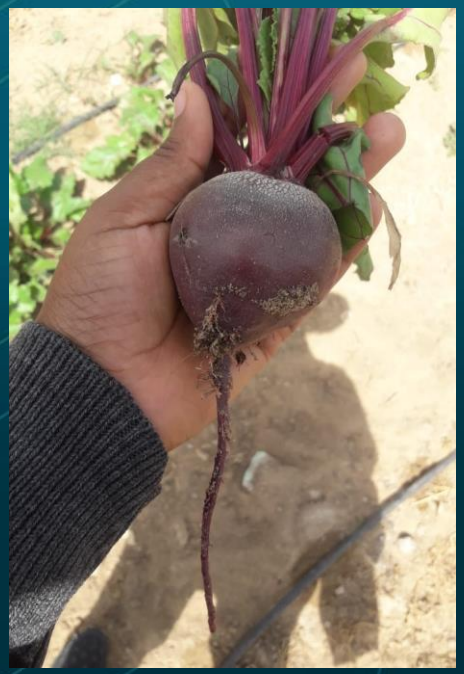
SEKEM



جامعة هليوبوليس
Heliopolis University
for Sustainable Development

Delphy

NECTÆRRA
water research & consulting

Improving crop, soil & water management under saline conditions

Nuffic

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Orange Knowledge Program, Nuffic (NL)

The Salt Doctors

Implementation Pakistan, salt tolerant potato (2016-2017)

JAFFER

META

SaltFarm Texel

SECURING WATER FOR FOOD: A GRAND CHALLENGE FOR DEVELOPMENT

In Pakistan, 6 million hectares of salt affected farm land

Activities: validation and demonstration salt tolerant potato, introduction at field scale, training, capacity building and marketing

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Result: 28% yield increase under moderate saline conditions, compared to the local variety (average soil salinity = 8 dS/m)

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Implementation Kenya, salt tolerant carrot, 2018

NECTÆRRA water research & consulting

Delphy

SaltFarm Texel Tested on Texel

Activities: tailor-made cultivation strategy salt tolerant carrot, training, capacity building and marketing, smart water management (water harvesting), develop approach for agro-forestry

Results: 94% yield increase compared to local variety, model for 98% groundwater use reduction

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Netherlands Enterprise Agency

The Salt Doctors

Implementation Bangladesh (2017-2020)

From 1 crop season per year > 2-3 seasons

Saline Farming

Results

-after 2 years, based on independent project evaluation-
260 random surveys from 1920 group farmers and 80 lead farmers

icco

- **Food security increased from 15% to 65%**
  - Based on Household Food Insecurity Access Scale-0 (full food security)
- **Use of salt affected fallow land** increased from 0% to 76%

2 ZERO HUNGER

13 CLIMATE ACTION

- average household **income increased by 34%**
- Percentage with more than 100 euro increase:
  - 55% for lead farmer, 4% for group farmer
- **Employment increased** by 10% for lead farmer, 41% for group farmer

1 NO POVERTY

- **Vegetable consumption** (150 g/day, 10 months/year) **increased** from 26% to 74%
- Household **improved dietary diversity** increased from 75% to 100%

3 GOOD HEALTH AND WELL-BEING

17 PARTNERSHIPS FOR THE GOALS

- **Women with improved skills** for sustainable food production increased from 9% to 79%
- **Access to land for women** increased from 4% to 87%

5 GENDER EQUALITY

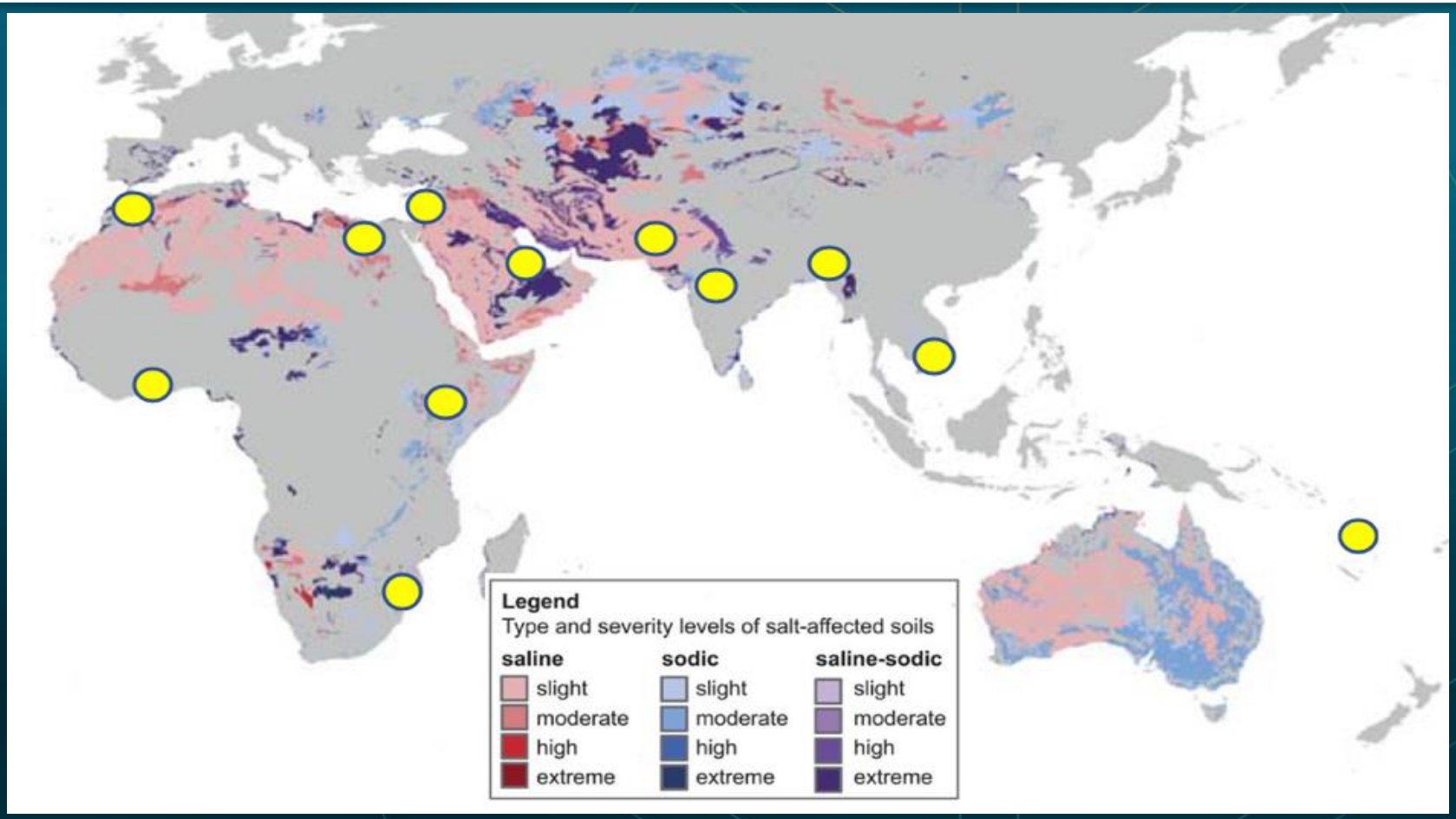
Supported by NATIONALE POSTCODE LOTERIJ

codec

Set up test facility, testing local crops for salt tolerance
Training-of-trainers, 200 lead farmers, 5000 group farmers
Providing knowledge, skills and seeds to the farmers

Ambition The Salt Doctors

The Salt Doctors



Realize global network, accelerate innovation and implementation, work towards large-scale impact

The SalFar project – soilexperts, microbiologists, economists, farmers, experts in watermanagement, regional planning, policy development, climate experts

Objectives

- Promote resource efficiency
- Testing salt tolerance of crops
- Test fields in regions around the North Sea
- Workshops for farmers and policy makers
- Creating new business opportunities for farmers
- Sharing knowledge and experience around the world

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provincie groningen

Interreg North Sea Region SalFar European Regional Development Fund EUROPEAN UNION

Challenges

- (moderately) tolerant varieties of conventional crops have been identified, but salt tolerance often not interesting (yet) for breeders (?)

- Yield under saline conditions can be improved greatly, but also requires improved soil and water management...
  - This complexity makes implementation difficult (?)

- Saline agriculture is more than cultivating a salt tolerant crop
  - socio-economic factors: market opportunities for farmers, training, showcase results, with local problems asking for local solutions (tailor-made solutions...)

- First implementation shows that saline agriculture is possible and profitable, but how to move towards large-scale impact...?

- Conventional crops mostly for moderate saline conditions, can halophytes be used for high saline conditions?

3) Projects on Halophytes value chains in MENA region

Dionysia-Angeliki Lyra

E-mail address: d.lyra@biosaline.org.ae

International Center for Biosaline Agriculture (ICBA)

Mission: To work in partnership to deliver agricultural and water scarcity solutions in marginal environments to ensure sustainable livelihoods and food security.

Different uses of halophytes

Environmental and Experimental Botany 107 (2014) 71–83

Contents lists available at ScienceDirect

Environmental and Experimental Botany

journal homepage: www.elsevier.com/locate/envexpbot

Halophyte agriculture: Success stories

Suresh Panta [a], Tim Flowers [b], Peter Lane [a], Richard Doyle [a], Gabriel Haros [c], Sergey Shabala [a,*]

[a] School of Land and Food, University of Tasmania, Hobart, Australia
[b] School of Plant Biology, Faculty of Natural & Agricultural Sciences, The University of Western Australia, 35, Stirling Highway, Crawley, Western Australia, 6009, Australia
[c] The Punda Zoie Company Pty Ltd, Melbourne, Australia

Halophytes as…

1) **Human food:** quinoa, sea kale, (rock) samphire, pearl millet, etc.
2) **Forage & animal feeds:** Atriplex, Sporobolus, Distichlis, Paspalum, etc.
3) **Oilseed crops:** Suaeda, Kosteletzkya, Salicornia etc.
4) **Energy crops:** Tamarix, Phragmites, Miscanthus, Spartina, Typha etc.
5) **Phytoremediation:** Sesuvium, Atriplex, Salicornia etc.
6) **Medicinal plants:** Ipomoea, Tamarix, Pandanus, Iceplant, etc.

A. Quinoa

Nutritional value

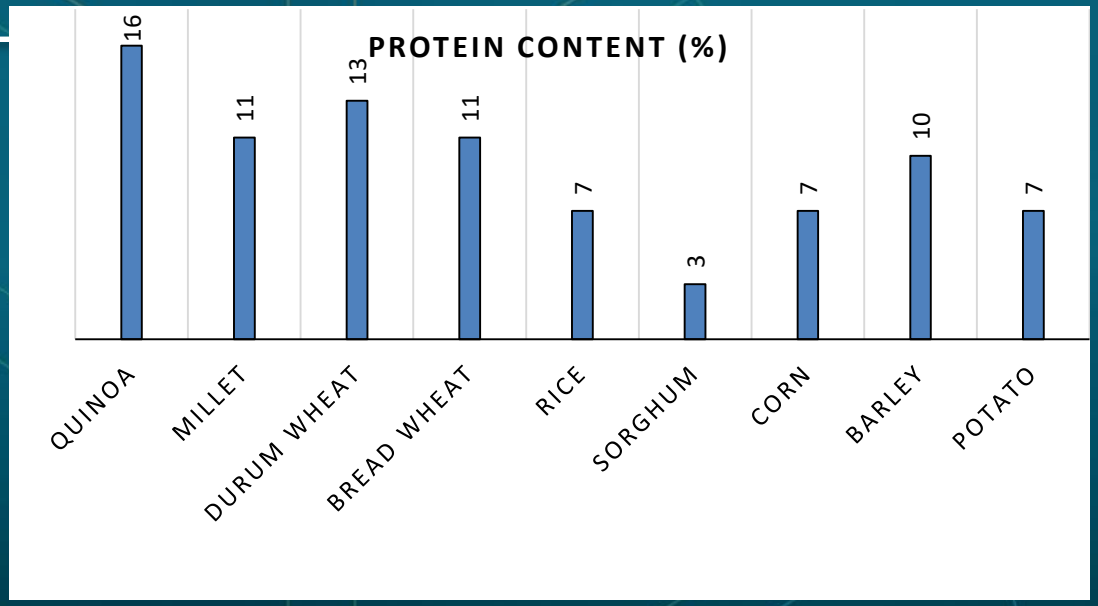


Table 3: Mineral content of quinoa and selected foods, mg/100g dry weight

	Quinoa	Maize	Rice	Wheat
Calcium	148.7	17.1	6.9	50.3
Iron	13.2	2.1	0.7	3.8
Magnesium	249.6	137.1	73.5	169.4
Phosphorus	383.7	292.6	137.8	467.7
Potassium	926.7	377.1	118.3	578.3
Zinc	4.4	2.9	0.6	4.7

Source: Koziol (1992)


Quinoa
Rehamna

A.2. Kyrgyzstan: Development of Quinoa Value Chain

Pioneer farmer Azamat Kaseev, Kyrgyzstan

- ✓ 2.5 kg of seed sown in 1 ha → provides up to three tones of quinoa seed
- ✓ Quinoa retail price goes up to 700 Kyrgyz soms per kilogram (10 USD), while seeds can fetch up to 2,000 Kyrgyz soms per kilogram (28 USD)

КЫРГЫЗ РЕСПУБЛИКАСЫ

КЫРГЫЗПАТЕНТ

ПАТЕНТ

№ 2088

Ойлоп табуунун атальшы:

Патент эсси, өлкөсү:

Автору (авторлору):

Өтүнмөнүн №

Ойлоп табуунун артыкчылыгы:

KYRGYZPATENT

Кыргыз Республикасынын Ойлоп табуулардын мамлекеттик реестринде каттелген:

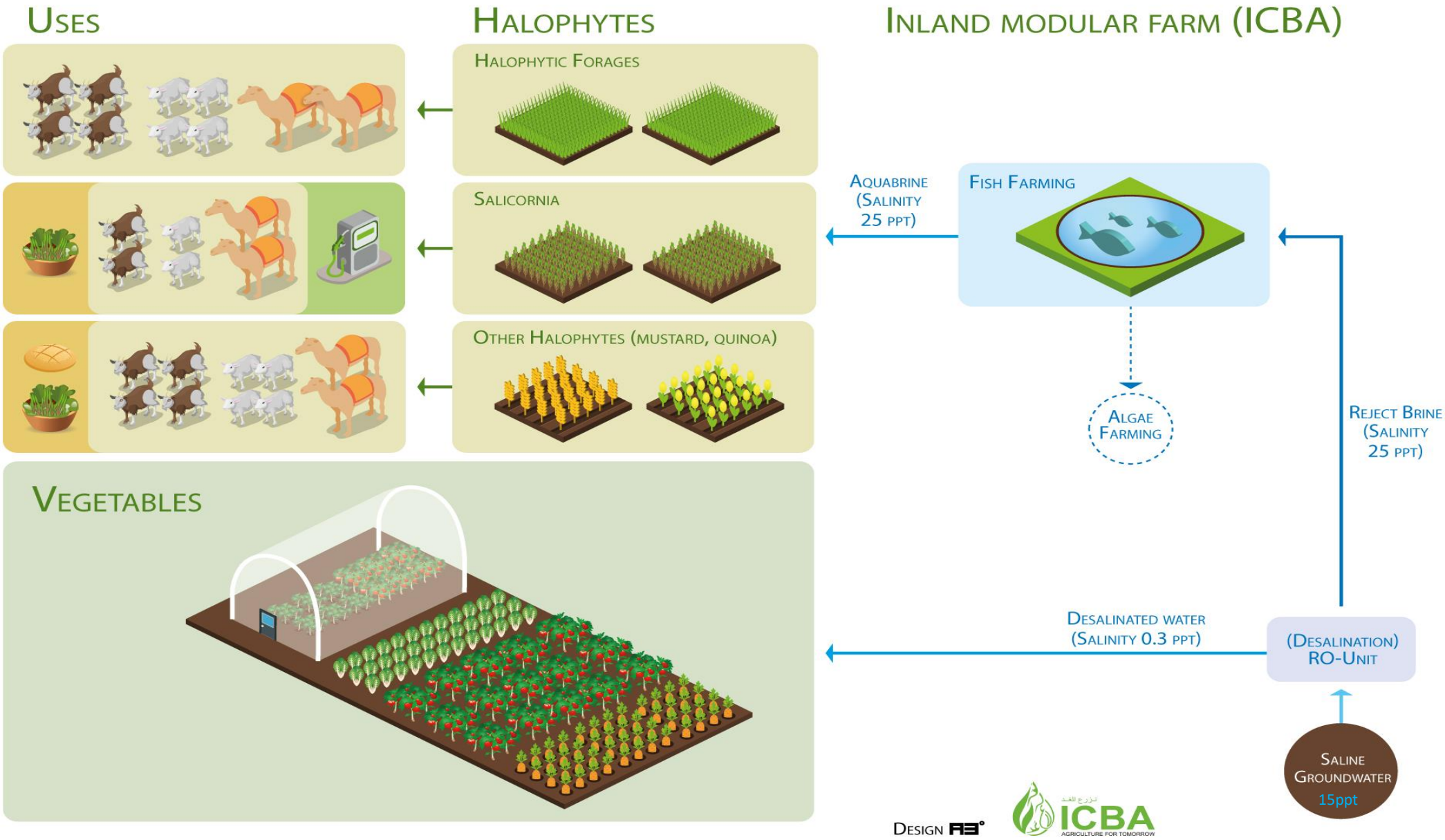
B. Salicornia (sea asparagus, samphire)

Uses

Healthy benefits

- ✓ Minerals content show that Salicornia is better than asparagus. More sugar and healthy MUFA and PUFA fats; more fiber, more calcium, magnesium and manganese.
- ✓ Calcium and magnesium are good for healthy bones.
- ✓ Calcium, magnesium, potassium and chloride all are important for nerve function and impulses, muscular contraction and heart/cardiac health.

Inland integrated agri-aquaculture farms developed by ICBA



Develop a sustainable halophyte-based industry model in a desert environment that could be further replicated

Halophytic dishes (2018)

Salicornia jelly

Crackers of Salicornia and rock samphire

Rock samphire smoked tilapia with quinoa

Salicornia juice

Salicornia and rock samphire bread

Halophytic products (2019 - 2020)

Salicornia burger

Salicornia cheesecake with camel milk and cheese

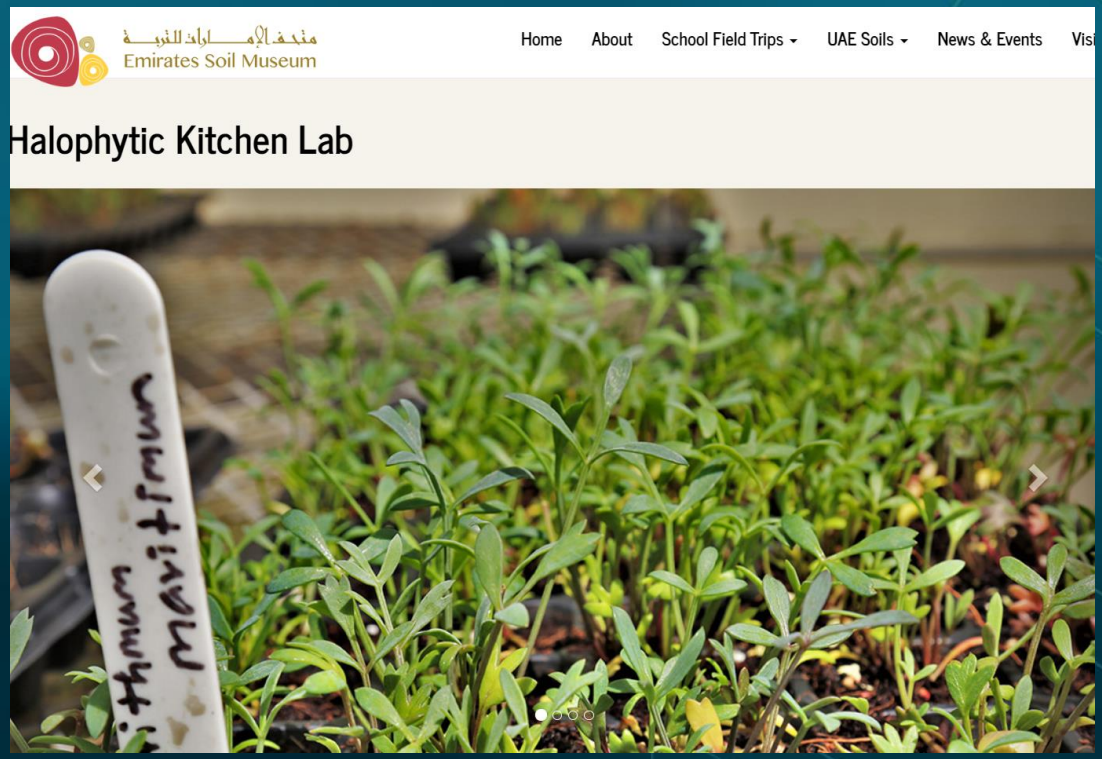
Salicornia biscuit

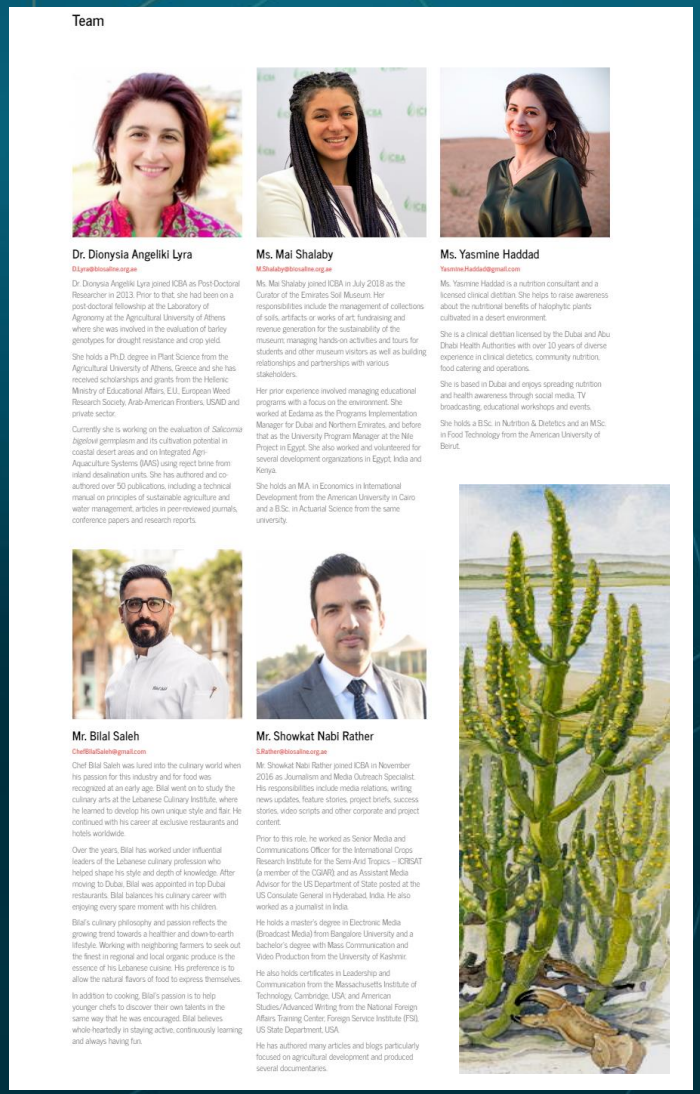
Salicornia smoothie

Salicornia crackers

جلوبال للصناعات الغذائية ذ.م.م
GLOBAL FOOD INDUSTRIES LLC

Halophytic Kitchen Lab Program (2019 - 2020)





https://www.emiratessoilmuseum.org/education-programs/university-programs/halophytic-kitchen-lab

...to raise public awareness on halophytes

B.2. Building Sustainable Networks and Unleashing Entrepreneurial Potential in Farming Communities living in Marginal Areas

Development of quinoa value chain in Egypt

- Development & implementation of business model
- Development of a seed production unit for quinoa
- Capacity building

Salicornia production trials in Egypt

- Establishment of Salicornia
- Assessment of demand
- Farmers' training

Training on integrated farming in UAE

- Training videos translated in Urdu, Arabic for farm workers
- Smart applications

Partners

مركز بحوث الصحراء
DESERT RESEARCH CENTER

ECESA
Egyptian Center of Excellence for Saline Agriculture

EACDP

SMART LABOUR

B.2. Building Sustainable Networks and Unleashing Entrepreneurial Potential in Farming Communities living in Marginal Areas

Quinoa

Quinoa-olive fruit paste

Quinoa condiment mixed with herbs and spices

Quinoa biscuits

Salicornia (primarily as feed)

Halophytic food products

Cosmetics products based on local Halophytes

Challenges

- Improved halophytic germplasm
- Mechanization of the harvest and seeds cleaning processes
- Customize the halophytic production on the local climatic & socioeconomic context
- Sustainability of Saline Agriculture projects (All 3 pillars)
- Creating the market segment for halophytes
- Convincing the consumers
- Training the farmers to use saline water resources sustainably

4) Implementation of a Decision Support Tool (DST) under saline conditions. A showcase of the Mediterranean Region

Andrés Parra González

CEBAS CENTRO DE EDAFOLOGÍA Y BIOLOGÍA APLICADA DEL SEGURA

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

E-mail address: aparra@cebas.csic.es

Mission: To generate necessary knowledge through research to achieve the sustainability of the scant resources in semiarid areas, focusing on their proper management, making possible the development of a quality agriculture to obtain healthy and safe food

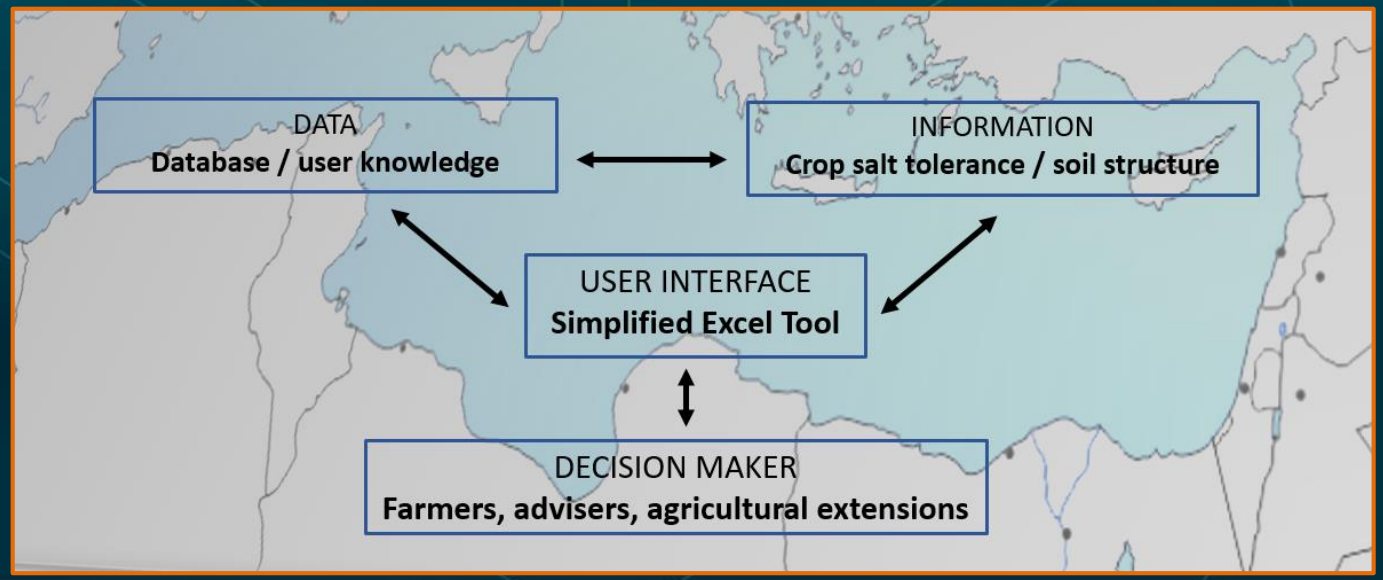
General facts at farm level

- Non-efficient irrigation systems
- Different water sources, qualities and availability
- Multiple crops under the same irrigation regime
- Limited reliance on non-conventional waters:
  - saline, brackish, brine, reclaimed waste waters…
- Predominance of low-cost technologies
- Lack of awareness/access to modern solutions

A DST to manage different water sources

Help farmers to contrast information provided by the DST with their personal knowledge and experiences

- Examination of multiple alternatives
- Identification of unpredicted situations
- Better use of data and resources
- Reduce costs



PROSIM

ENI CBCMED

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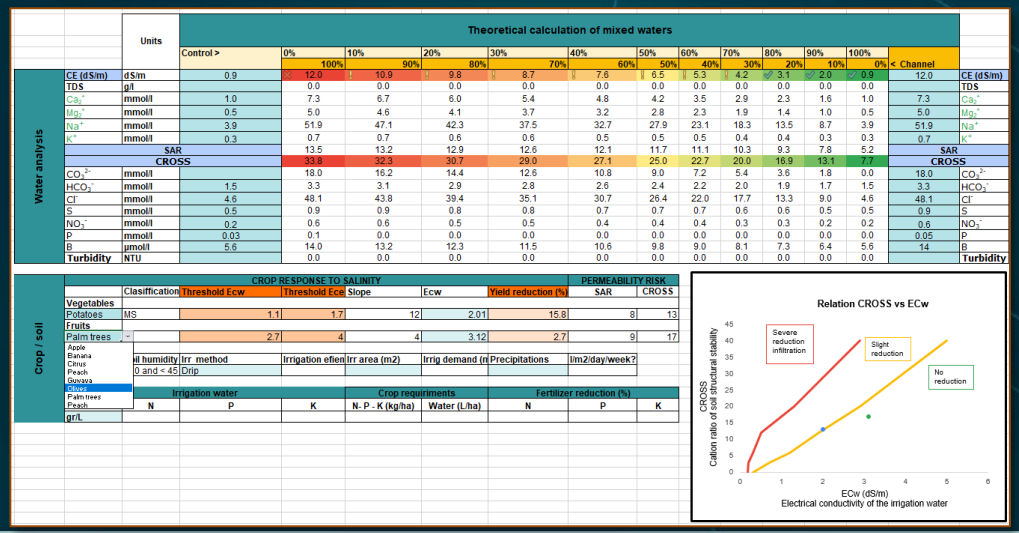
The Excel Tool

Input parameters

- Water and soil analysis
- Crop:
  - Variety /rootstock
  - Density
  - Growth stage/age
- Irrigation method

Output

- Relative crop performance and recomendations:
  - Suitable stages for using different water qualities
  - Possible benefits on fruit quality
  - Toxicity hazards
- Water quality and soil structure info (SAR/CROSS)
- Fertilizer recomendations



		Units	Theoretical calculation of mixed waters														
			Control >	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	< Channel	
				100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%		
Water analysis	CE (dS/m)	dS/m	0.9	12.0	10.9	9.8	8.7	7.6	6.5	5.3	4.2	3.1	2.0	0.9	12.0	CE (dS/m)
	TDS	g/l		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		TDS
	Ca_2^+	mmol/l	1.0	7.3	6.7	6.0	5.4	4.8	4.2	3.5	2.9	2.3	1.6	1.0	7.3	Ca_2^+
	Mg_2^+	mmol/l	0.5	5.0	4.6	4.1	3.7	3.2	2.8	2.3	1.9	1.4	1.0	0.5	5.0	Mg_2^+
	Na^+	mmol/l	3.9	51.9	47.1	42.3	37.5	32.7	27.9	23.1	18.3	13.5	8.7	3.9	51.9	Na^+
	K^+	mmol/l	0.3	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.7	K^+
	SAR			13.5	13.2	12.9	12.6	12.1	11.7	11.1	10.3	9.3	7.8	5.2	SAR	
	CROSS			33.8	32.3	30.7	29.0	27.1	25.0	22.7	20.0	16.9	13.1	7.7	CROSS	
	CO_3^{2-}	mmol/l		18.0	16.2	14.4	12.6	10.8	9.0	7.2	5.4	3.6	1.8	0.0	18.0	CO_3^{2-}
	HCO_3^-	mmol/l	1.5	3.3	3.1	2.9	2.8	2.6	2.4	2.2	2.0	1.9	1.7	1.5	3.3	HCO_3^-
	Cl^-	mmol/l	4.6	48.1	43.8	39.4	35.1	30.7	26.4	22.0	17.7	13.3	9.0	4.6	48.1	Cl^-
	S	mmol/l	0.5	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.9	S
	NO_3^-	mmol/l	0.2	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.6	NO_3^-
	P	mmol/l	0.03	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	P
	B	µmol/l	5.6	14.0	13.2	12.3	11.5	10.6	9.8	9.0	8.1	7.3	6.4	5.6	14	B
	Turbidity	NTU		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		Turbidity

		CROP RESPONSE TO SALINITY					PERMEABILITY RISK	
	Clasiffication	Threshold Ecw	Threshold Ece	Slope	Ecw	Yield reduction (%)	SAR	CROSS
Vegetables								
Potatoes	MS	1.1	1.7	12	2.01	15.8	8	13
Fruits								
Palm trees		2.7	4	4	3.12	2.7	9	17
Apple								
Banana								
Citrus								
Peach								
Guavava								
Citrus								
Palm trees								
Peach								

	il humidity	Irr method	Irrigation efien	Irr area (m2)	Irrig demand (n	Precipitations	l/m2/day/week?
	0 and < 45	Drip					

	Irrigation water			Crop requirments		Fertilizer reduction (%)		
	N	P	K	N- P - K (kg/ha)	Water (L/ha)	N	P	K
gr/L								

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Challenges

Several options to reduce the pressure on freshwater resources…

- Explore different scenarios though a reliable, cheap and quick way
- First stage, general information
- Next steps?
    - more crops/ varieties (site-specific)
    - more parameters (crop ET/LF/turbidity/TSS…)
    - Database up to date
    - DST app-based?

Conclusions

1. Saline Agriculture is feasible in salt-affected areas through multidisciplinary approaches

2. Tailormade and sustainable solutions

3. Proper technical cultivation practices package: improved germplasm; effective management practices and pre - / post- harvest processes

4. Developing the value chain of halophytic products is imperative

5. Raising public awareness initiatives on halophytes → create the market segment

6. Training and capacity building programs are very much needed

7. Digital technologies can facilitate the saline agriculture activities

8. Preservation & Enhancement of agrobiodiversity within saline agroecosystems

Save the date...

Food and Agriculture Organization of the United Nations

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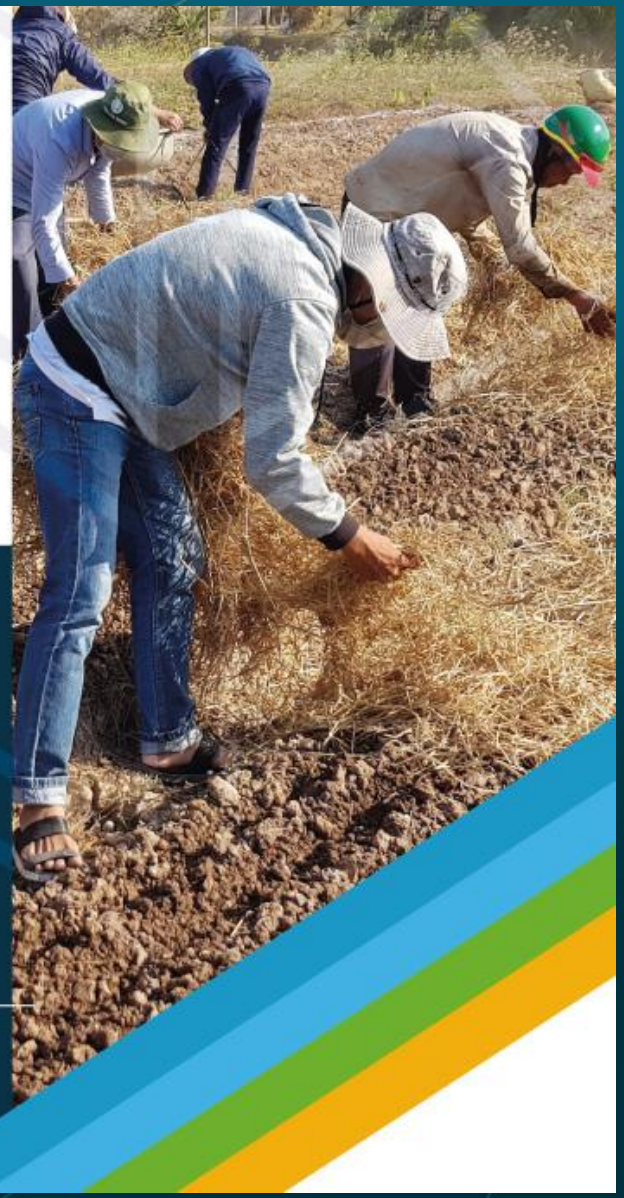

WEBINAR 3

Water and soil management in salt affected areas

TUESDAY 2 JUNE 2020 | 15:00 – 16:30 CET

Thank you