Desalination Technologies and the Food System

an integrated approach to water management in Deltas under Pressure

Tania Mubita Zambrano & Tossa Harding, WUR

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WUR KB Project Deltas: Salinity & Drought

Contribute to Zero Hunger (SDG2) by combining our interdisciplinary knowledge in the agri-food and water domains to shape the transitions towards sustainable food systems

- Research project Food Security and the Value of Water
- Phase 1, 2019 – 2022: Deltas under Pressure
- Phase 2, 2023 - 2024: Salinity & Drought
- Case Studies: Mekong River Delta & Bangladesh
- Vietnam: in collaboration with Can Tho & Tra Vinh
- Analytical Framework: **Food Systems Approach**

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Link to project overview: Food system transitions in deltas under pressure - WUR

Sharing lessons learned

Program:

- Context & problem definition Deltas under Pressure
- Why, what & how of a Food Systems Approach
- Food Systems Transformation & Transition Pathways
- Zooming in on Salinity
- Desalination technologies
- Reflection on the role of research in FST

Context: the importance of Deltas

- Agricultural Productivity
- Economic Opportunities
- Water Resources
- Biodiversity & Ecosystem Services
- Cultural Significance
- Climate Resilience
- Livelihoods

Deltas under Pressure

Key challenges facing deltas:

- Balance economic growth & environmental sustainability
- Growing urban population and industrialization
- Change in dietary patterns (animal protein)
- Climate Change: extreme events, floods, drought, sea level rise, salinization

→ Resource degradation and increased competition for land

Research aim: To examine and build on the current situation, and define actions and changes in the food system that support transition towards sustainable and climate resilient food system

Salinization & Drought

Agriculture increasingly affected

- Multiple causes
- Societal problem (soil, animal, human health, livelihoods, Food Security, migration)
- Connects local and global
- High complexity
- Multiple stakeholders

Salinisation is a global issue

Current estimate: 20% of cultivated land affected. Areas are increasing at a rate of 1-2 million ha/year.

Food Systems Approach

Research aim: Formulate possible solutions for food related challenges in Deltas under pressure of climate induced salinisation and drought → integrated approach needed

Food Systems– UN, FAO, IFAD,…

ifad.org/en/food-systems

Food systems are made up of all the activities that feed people, from growing and processing, to packaging and marketing food. They include diets, cultural practices, prices and other factors that shape the demand for and consumption of food.

Food systems encompass all the elements that underlie how food gets from the field to our plates: people, processes, infrastructures, institutions, and the natural environment.

Transforming on a global scale

In 2021, the United Nations Secretary-General convened the **Food Systems Summit** in collaboration with the Rome-based UN agencies (FAO, IFAD, WFP), the UN Food System Coordination Hub and the wider UN system. This br together key players in every sector to develop solu more sustainable, equitable, healthy and inclusive f systems. The 2023 **Stocktake** was an opportunity to commitments and assess progress since the summ

As part of this global movement, we are:

Shaping a sustainab transformation

As the only international financial institution with a mandate to

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"Good food for all, for today and tomorrow"

World Food Forum 2024

https://www.world-food-forum.org/

CORE MESSAGES

FAO, 2023 - State of Food and Agriculture https://www.fao.org/publications/home/fao-flagship-publications/the-state-of-food-and-agriculture/en

1 The value of agrifood systems is not in doubt. They provide nourishment, sustain economies and shape cultural identities. However, one must also consider the environmental, social and health hidden costs associated with these systems.

amount to 10 trillion dollars or more at 2020 purchasing power parity (PPP), revealing the urgent need to factor these costs into decision-making to transform agrifood systems.

6 Globally, the dominant quantified hidden costs

Why focus on food & agriculture

- **Food security & nutrition** – 800 million people are hungry, 2 billion are obese and experience serious health problems
- **Economic development & living income**:
  - 2 billion people depend on smallholder agriculture, most without a living income
- **Environmental sustainability** – Agriculture is responsible for 30% of GHG emissions, and 70% of freshwater use, and 80% of biodiversity loss.

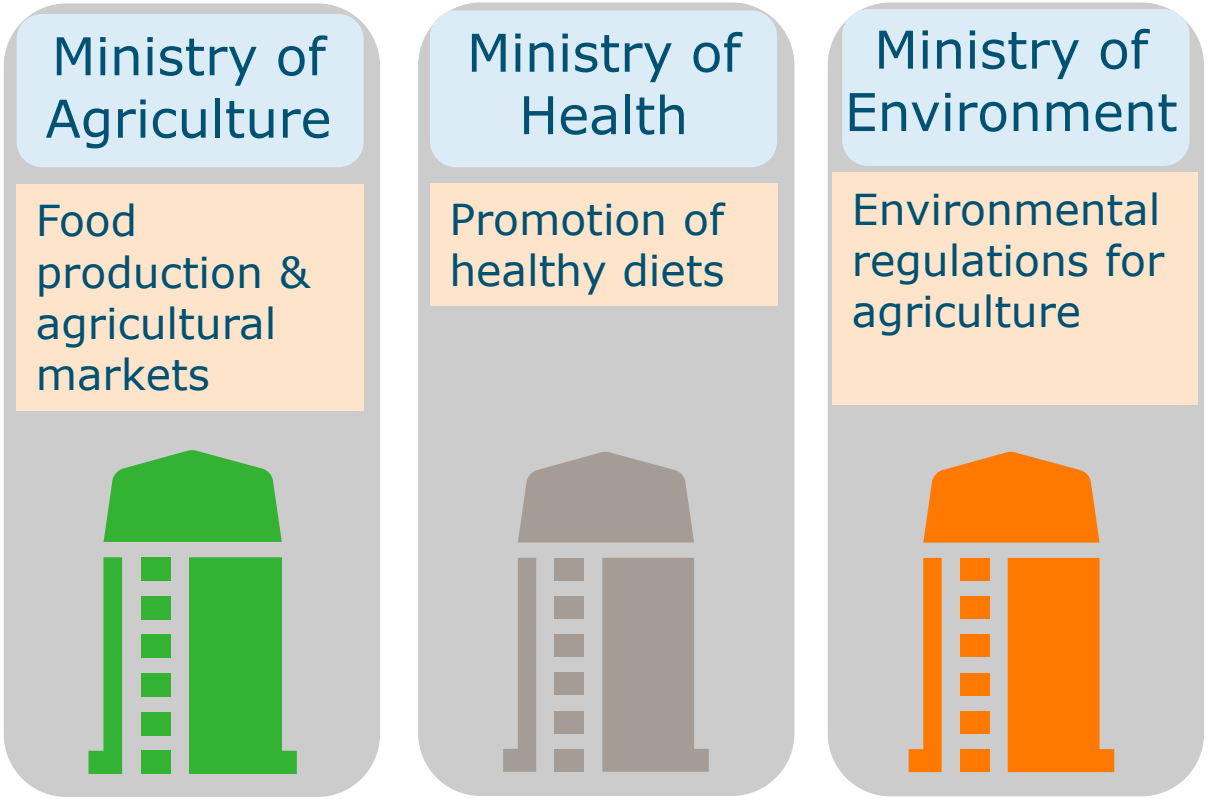
→**Undesired outcomes of current Food Systems**

→**Need to understand the processes behind these and identify leverage points for change**

Why a Food Systems Approach?

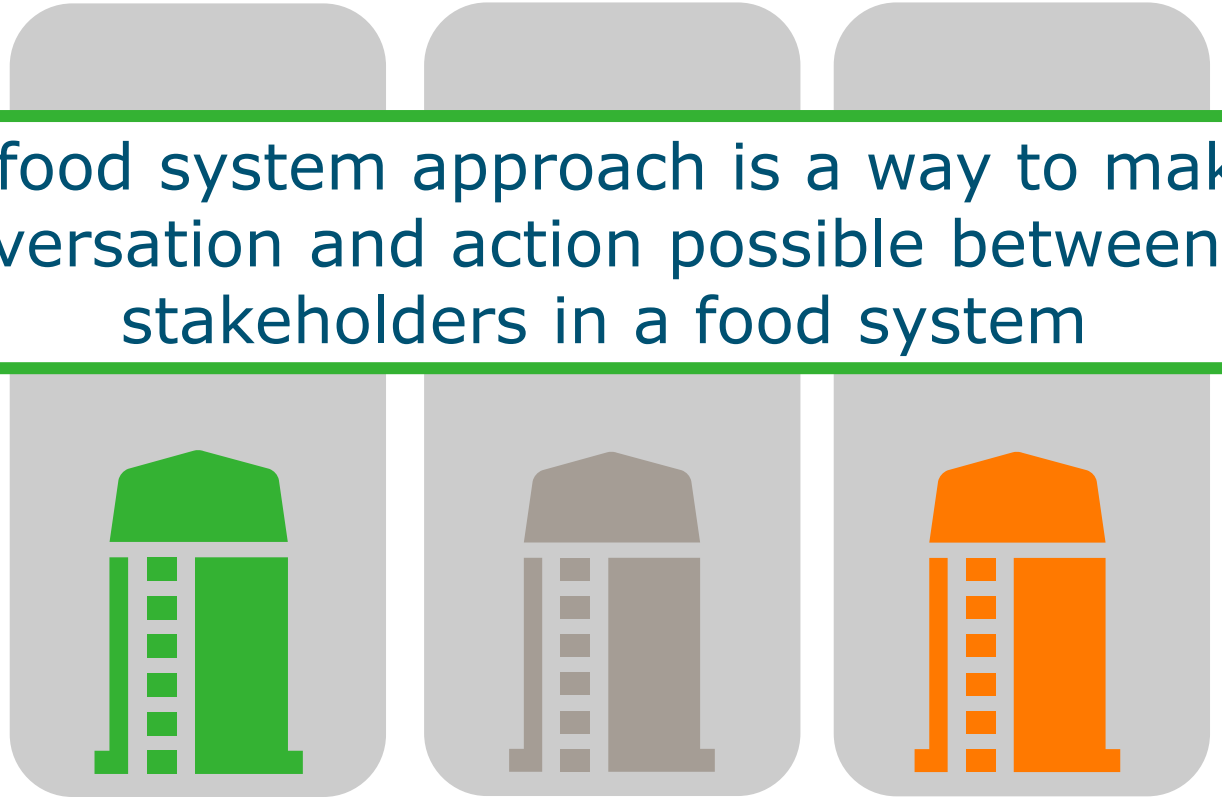
- Focus on production (intensification) alone does not work and creates additional problems
- Focus on food security not enough: nutrition & health
- Innovation of production technologies not enough
- Awareness of social and environmental costs of food production
- Local and global production and consumption patterns are connected
- Recognize and deal with synergies and trade-offs
- Need to work together across sectors and scales

Responses are often scattered



Food System “Silos” exist everywhere

A food system approach is a way to make conversation and action possible between **all** stakeholders in a food system



What do you think is a Food System?

Discuss with your neighbour:

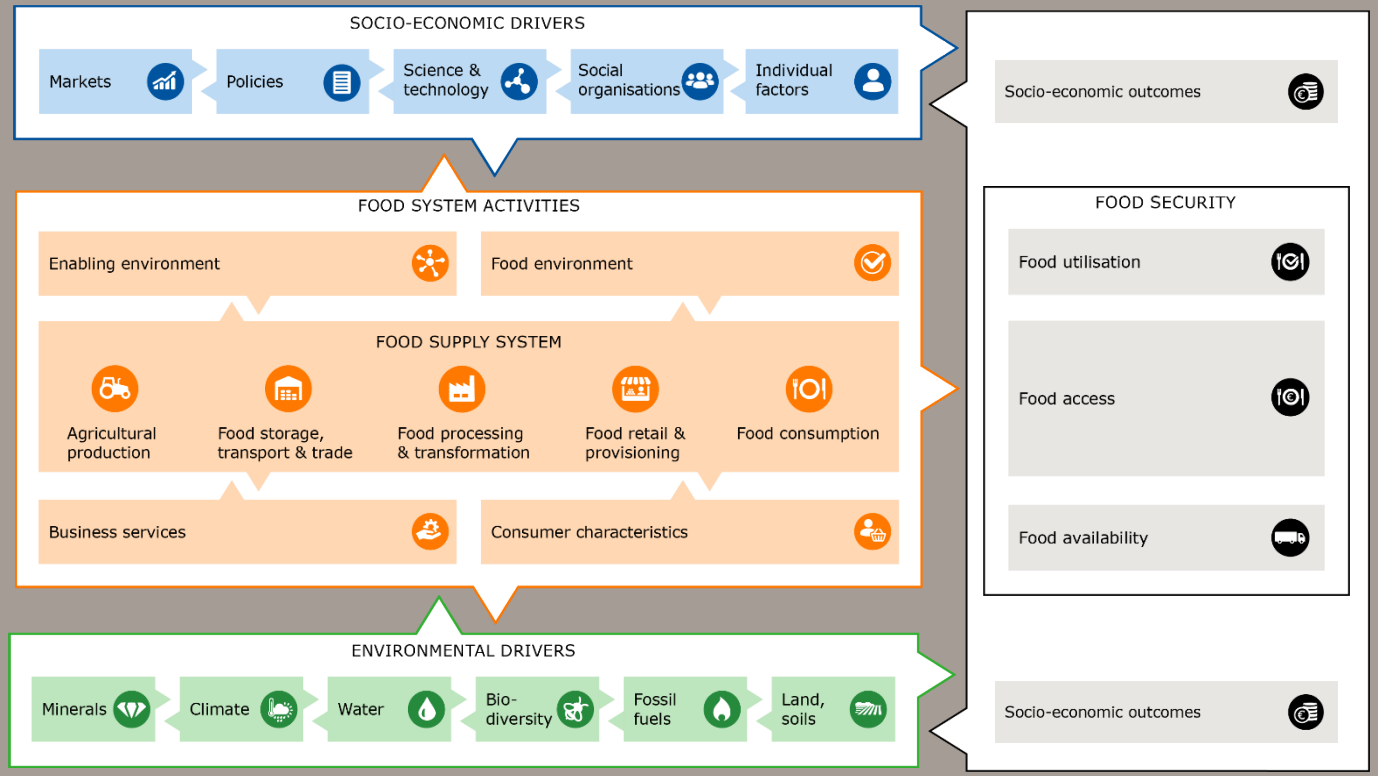
- Can you describe a food system in your surroundings?
- What elements does a food system contain?

Food system: from farm to fork and beyond






Food System Model



Food systems dynamics

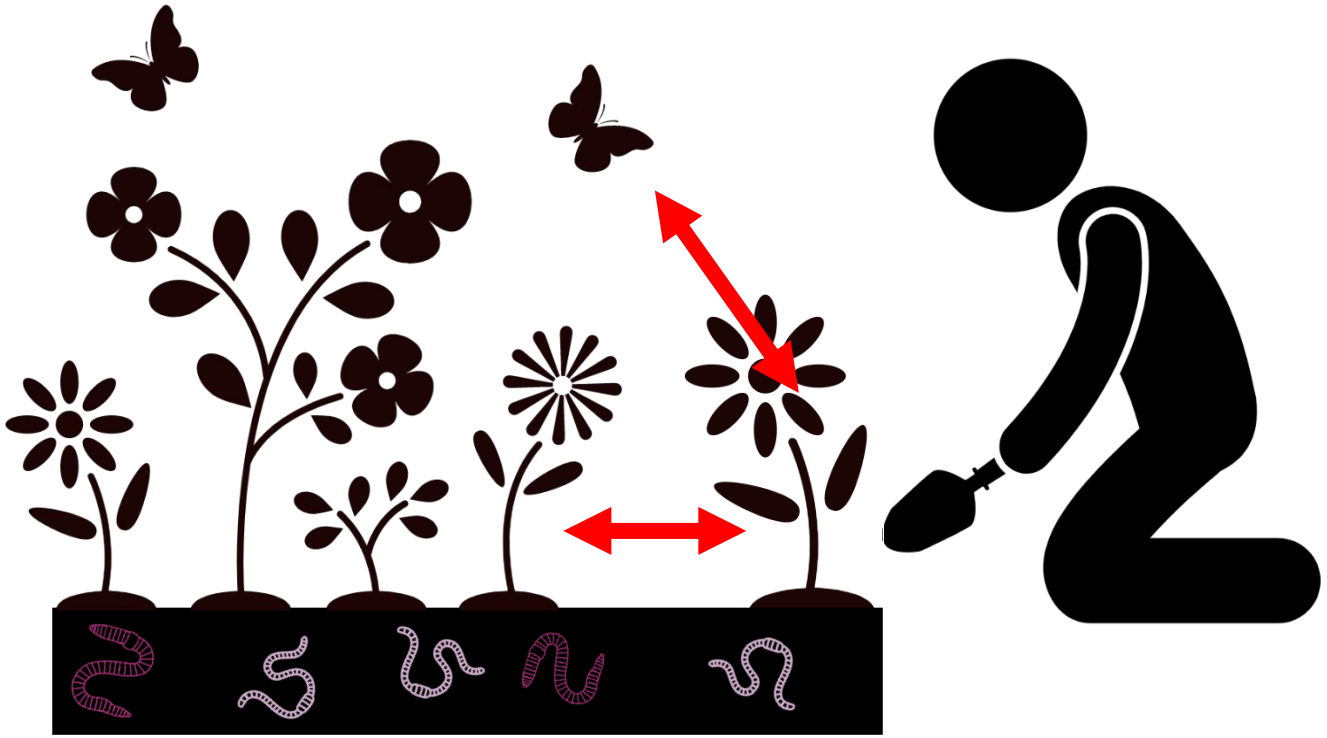
Static vs Dynamic & Interconnected

Fixing a bike...

Next time... same result.

Static vs Dynamic & Interconnected

Gardens...



Why a food system approach:

- Focusses on key drivers (zoom out & in)
- Goes beyond fixing symptoms towards building overall food system resilience
- Creates clarity about trade-offs and synergies
- Helps you decide on interventions by identifying leverage points for change
- Embraces complexity and collaboration

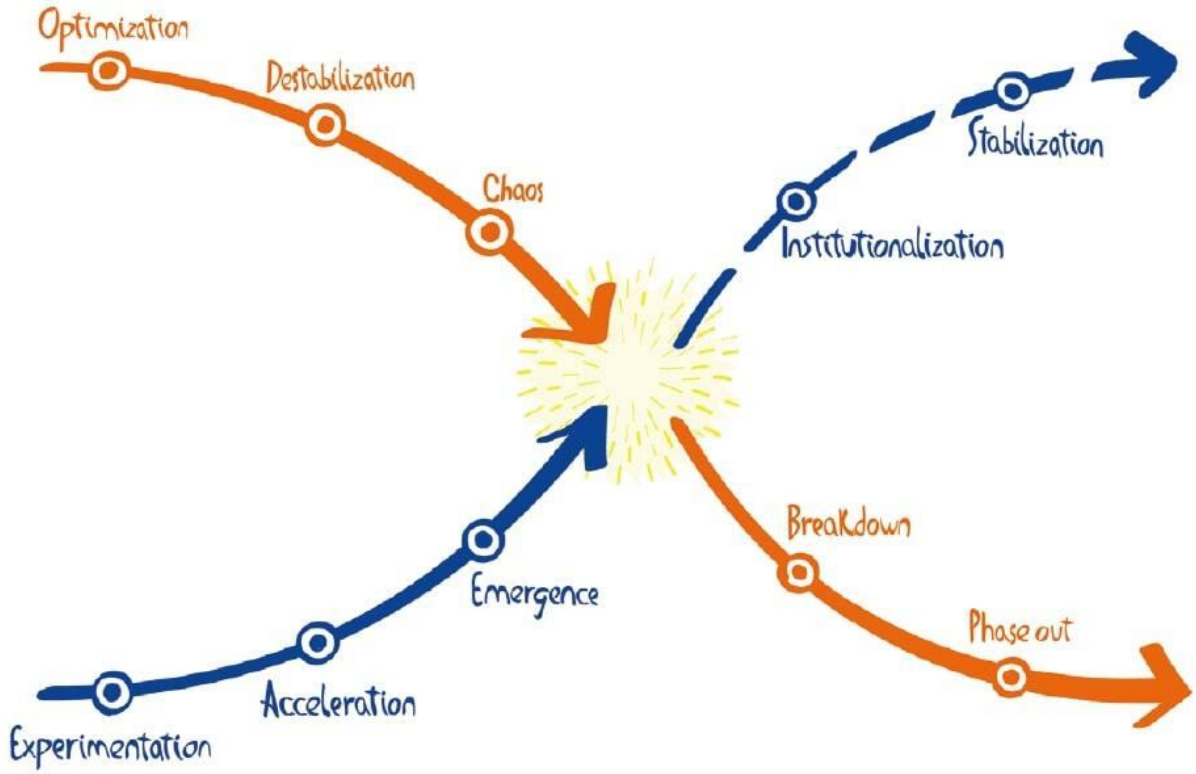
Food Systems Transformation

Not to tweak, adjust or improve but fundamental, structural change:

"Significant reconfigurations of the assemblages of Food System activities, actors, outcomes and relationships (dynamics) to move away from current globalized industrial model and ensure sustainable and just models of supply & consumption"

- Far reaching change: rethinking the desired outcomes, power relationships and the rules that shape food systems
- Cannot be steered, needs to be nudged
- Intentional, collective & inclusive, normative (values)

The transition curve

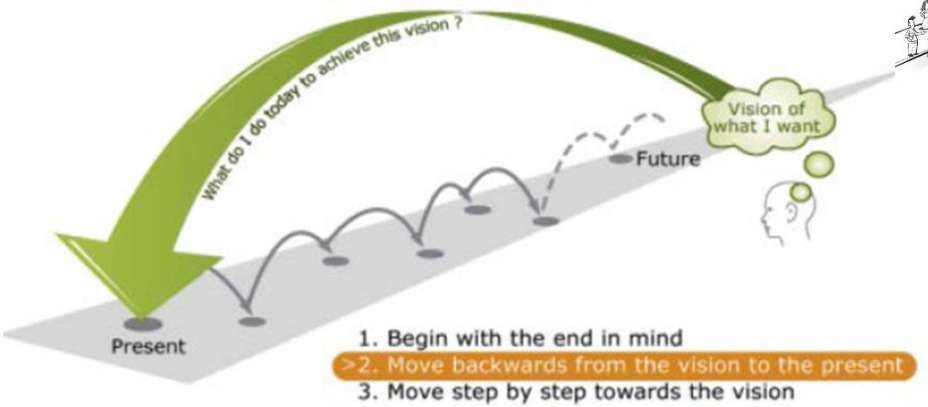


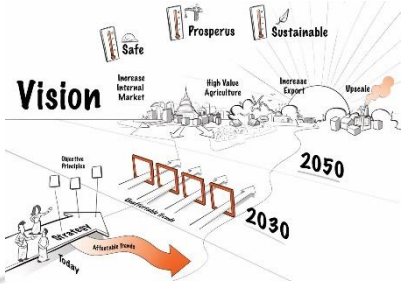
How can we influence transitions?

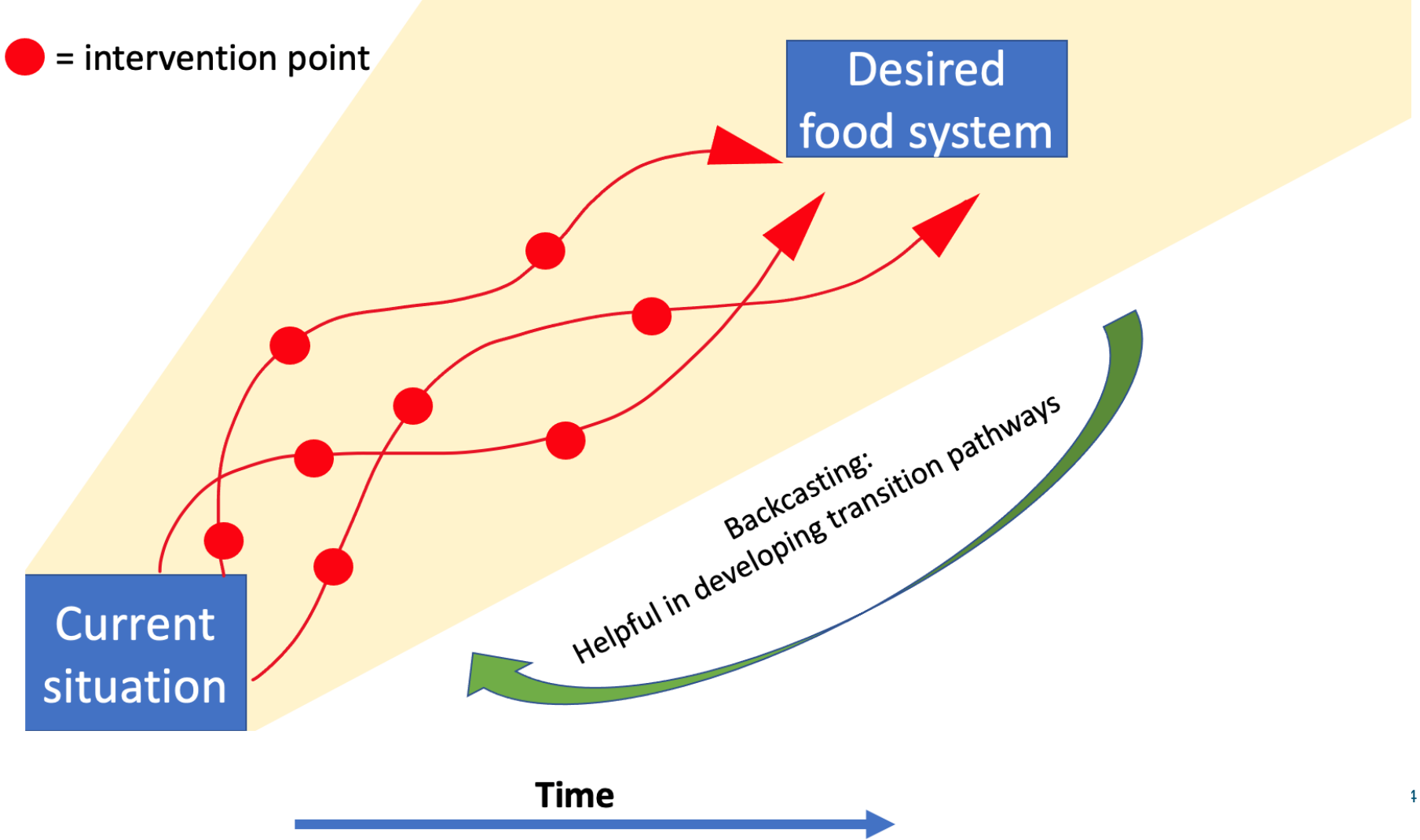
This project: Transition Pathways

- Exploring and analysing possible strategies for change
- Start by formulating one or more visions of a future sustainable Food System → with Stakeholders!
- Big change, may seem impossible to achieve
- Together explore incremental changes that might lead to present system to change into the vision

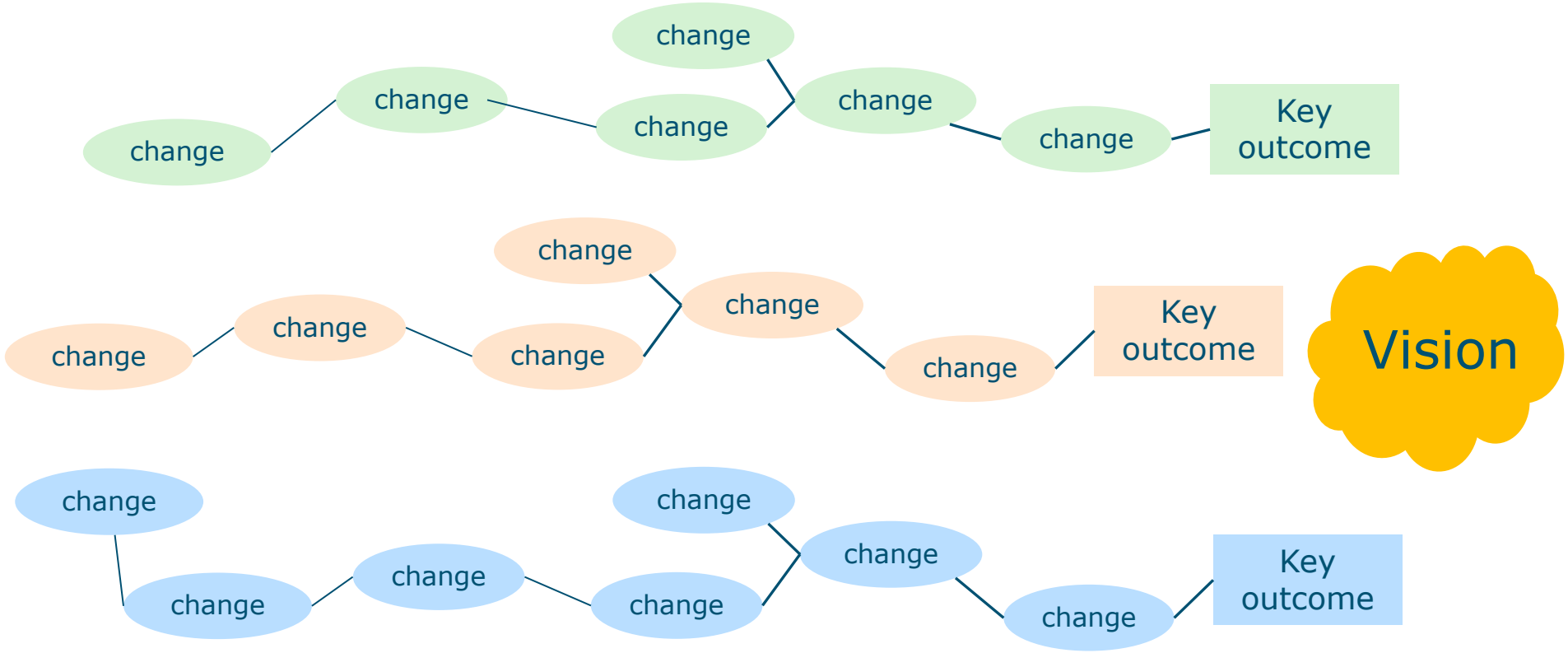
Visioning & Backcasting






= intervention point
Desired food system
Current situation
Backcasting:
Helpful in developing transition pathways
Time

Transition Pathways



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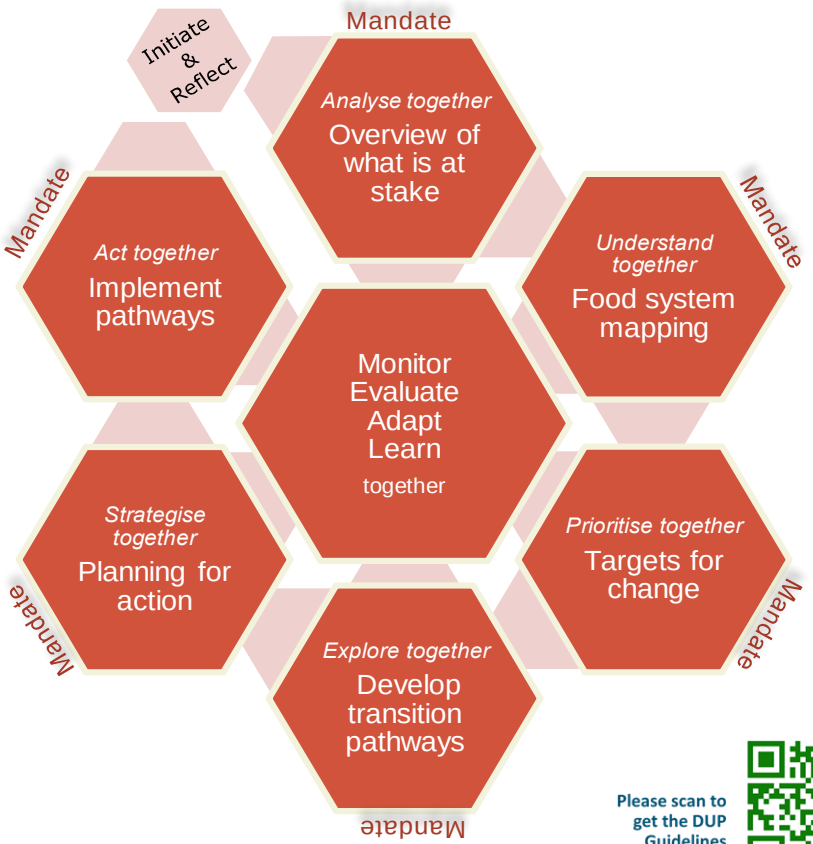
Transition pathways

- Use the food systems approach to explore the building blocks of transition pathways for agricultural production systems to adapt to the negative impacts of climate change in order to safeguard farmer’s livelihoods
- To structure activities and increase impact of potential food system transition pathways in deltas
- Important to involve Stakeholders, why?

Guideline for Agriculture System Change in Deltas

1. Analyse
2. Understand
3. Prioritise
4. Develop pathways for transition
5. Strategic action
6. Implement
7. Monitor, adapt and learn (cross-cutting)



Please scan to get the DUP Guidelines

(Verhagen et al, 2022)

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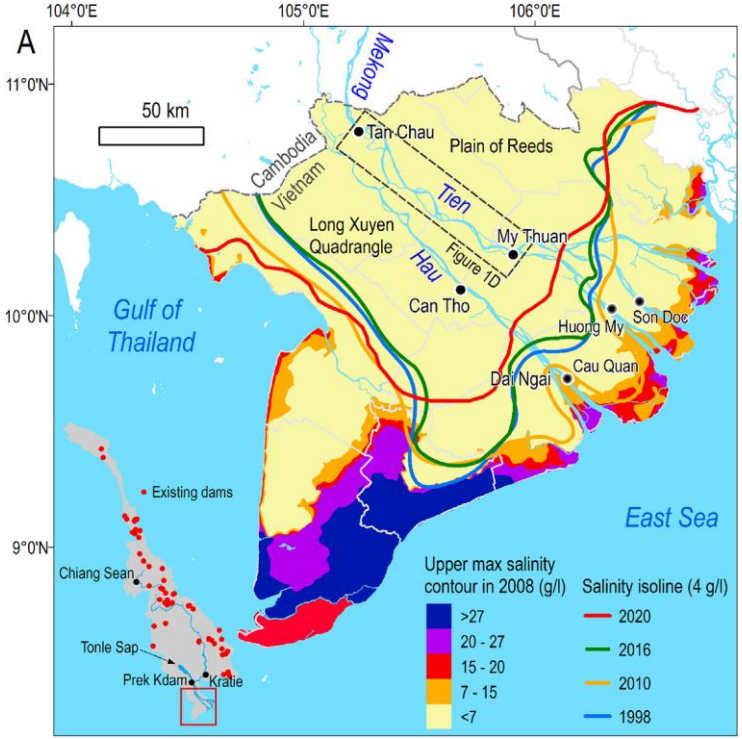
3 Pathways for Deltas under pressure of Salinity & Drought

1. Increasing crop production
2. Crop substitution
3. Implementation of desalination technologies

Salinity and its importance in water quality and agricultural productivity

The growing need for sustainable water solution: Saline intrusion during droughts period

Years 1998, 2010, 2016, 2020



- Colored areas represent salinity intrusion concentration across Vietnam in 2008.
- Lines illustrate the level of penetration of saline water into the in-land areas.
- Drought in 2020 had the most areas affected, followed by 2016.

Loc et al., Science of the Total Environment 757 (2021) 143919

The invisible threat to water and agriculture

Salinity → Amount of soluble salts in water

High

- Reduce crop yield by affecting plant metabolism and soil health.
- Alter the taste and safety of drinking water, posing health risks.

Class of water	EC (dS/m)	TDS (mg/L)	Suitability
Excellent	<0.25	<200	Most crops and soils
Good	0.25-0.75	200-500	
Permissible	0.75-2.00	500-1300	Leaching needed
Doubtful	2.00-3.00	1300-2000	Good drainage needed
Unsuitable	>3.00	>2000	Unsuitable for irrigation

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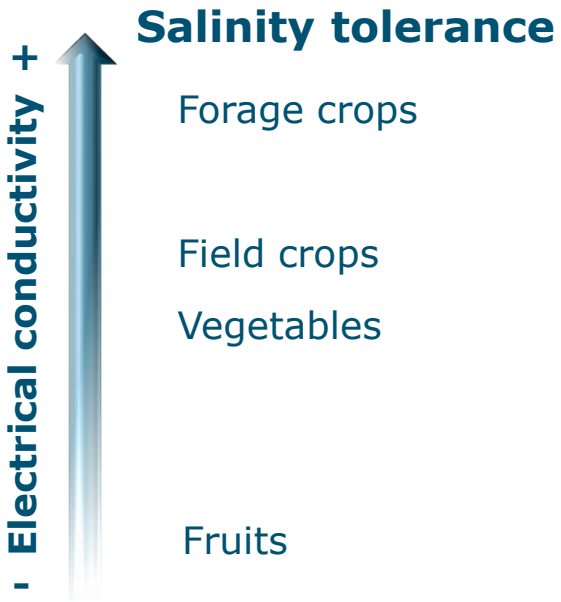
Irrigation water quality standards and salinity management strategies (tamu.edu)

Water quality matters: Salinity's impact on crop productivity



	Yield potential, EC_{iw} (dS/m)
Crop	**100%**
Quinoa	17*
Rice (paddy)	2.0
Corn	1.1
Beet	2.7
Sweet potato	1.0
Apple, pear	1.0
Almond	1.0

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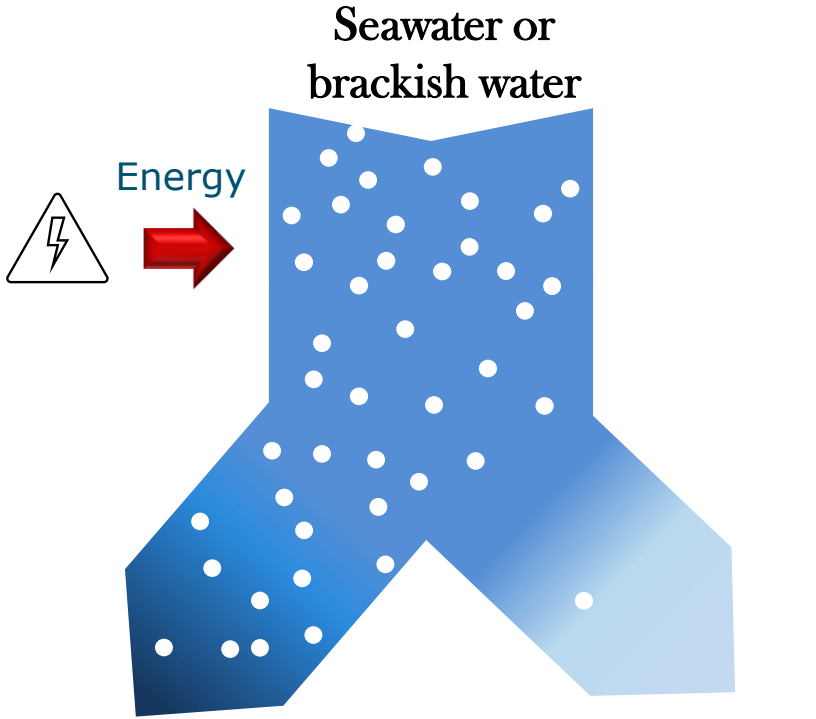
Irrigation water quality standards and salinity management strategies (tamu.edu)
* Plants | Free Full-Text | How Does Quinoa (Chenopodium quinoa Willd.) Respond to Phosphorus Fertilization and Irrigation Water Salinity? (mdpi.com)

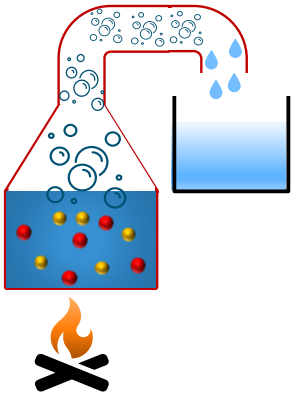
Desalination technologies: A path to sustainable water use for agriculture

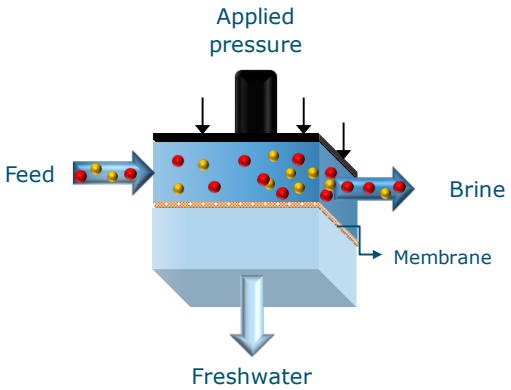
The science behind desalination

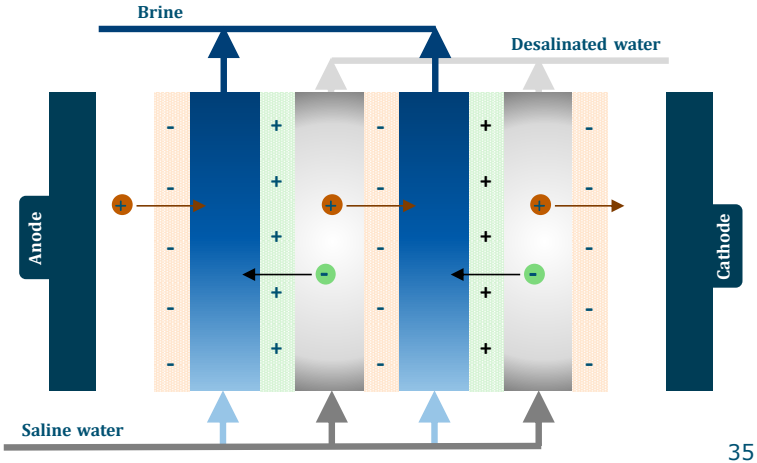


Desalination: A process in which freshwater and brines are produced from brackish or seawater

	Thermal		Membrane	
Technology	MSF	MED	RO	ED
Driving force	Heat		Pressure	Electrical potential







Multi-effect distillation (MED), multi-stage flash distillation (MSF), reverse osmosis (RO), electrodialysis (ED)

Desalination: A process in which freshwater and brines are produced from brackish or seawater

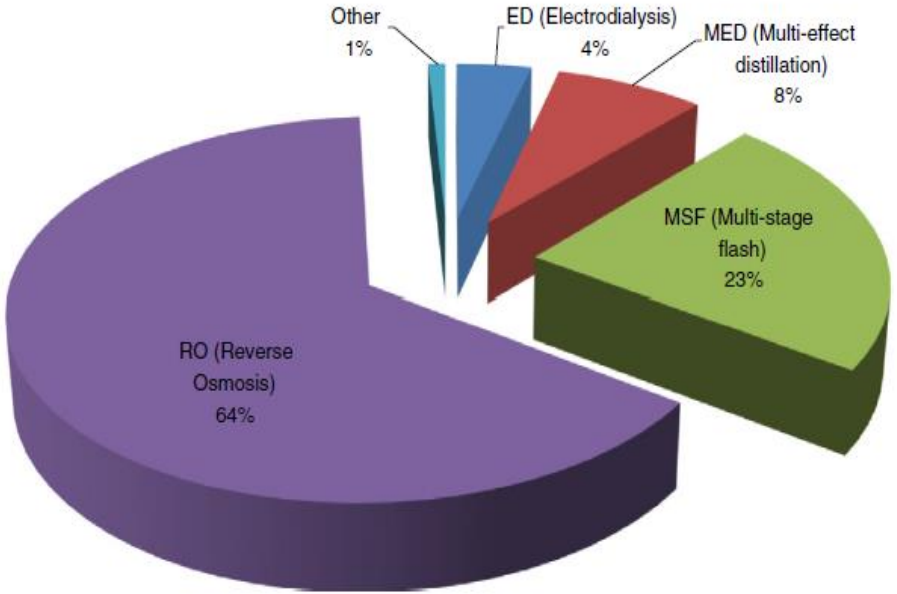
	Thermal		Membrane	
Technology	MSF	MED	RO	ED
Driving force	Heat		Pressure	Electrical potential
Electrical energy consumption (kWh/m³)	4.0-6.0	1.5-2.5	5.0-9.0	2.6-5.5
Thermal energy consumption (kJ/kg)	190-390	230-390	none	none
Unit product cost (USD/m³)	0.5-1.8	0.5-1.0	0.5-0.6	0.6-1.1

Multi-effect distillation (MED), multi-stage flash distillation (MSF), reverse osmosis (RO), electrodialysis (ED)

Do Thi, H., et al., ***Water,*** *13, 2021.* Comparison of Desalination Technologies Using Renewable Energy Sources with Life Cycle, PESTLE, and Multi-Criteria Decision Analyses

Desalination technologies share by capacity

Energy and Water interconnect



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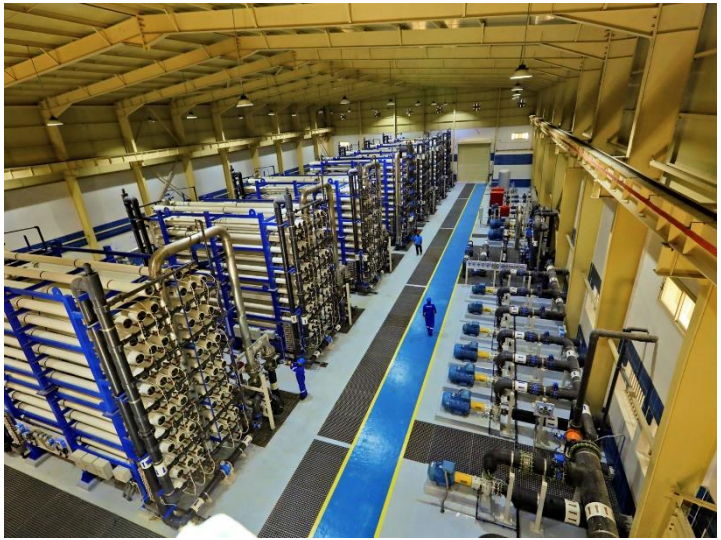
AlMarzooqi, F.A., et al., *Desalination*, **342,** 2014.

Modular design → all possible scales

Seawater Reverse Osmosis
Red Sea, Egypt
80,000 m³/day



https://www.metito.com/case_cat/seawater-reverse-osmosis-plant/

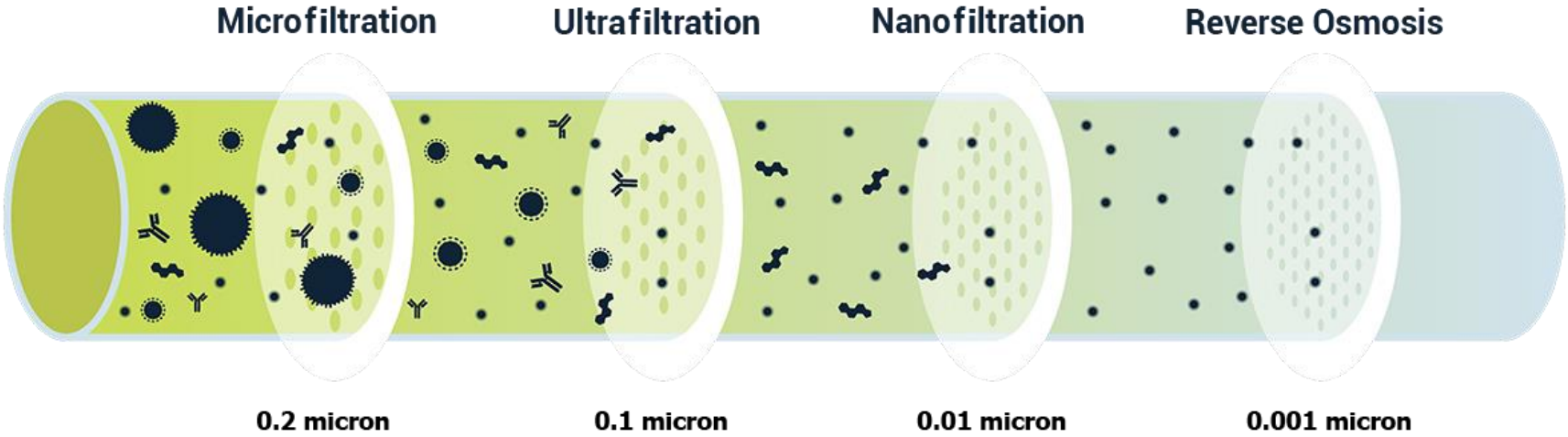
Groundwater Reverse Osmosis
Somalia
10 m³/day

Technical Briefing Note 26 – Desalination (2020) Oxfam

Water fit-for-use

- Current desalination technologies (RO, MSF, MED) excellent for producing potable water
  - very pure water → making very pure comes at a cost
- But...
  - we do not need very pure water for agricultural purposes
  - we do not need seawater to produce fresh water
- Water fit-for use
  - only remove salt that is necessary
    - more efficient proces, save energy, cheaper

Pressure driven membrane processes



- Suspended particles
- Macromolecules
- Bacteria

- Viruses
- Colloidal organic matter
- Oil

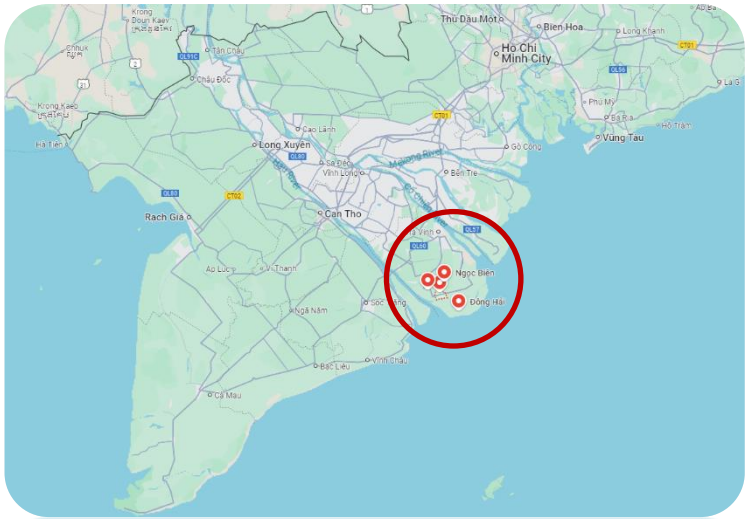
- Multivalent ions
- Organic compounds

- Monovalent dissolved salts

Polymeric Membranes (commercialmembranes.com)

What additional factors should be considered when implementing desalination technologies in the Mekong Delta?

Engaging farmers in Vietnam: Field trip conducted in March 2024



Group interviews with 31 farmers from the communes of

- Ham Giang
- Ngoc Bien
- Dong Hai
- Don Xuan in Vietnam

Among the farmers interviewed, 13% were women

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Insights from the field: Strategies implemented during dry season

High water salinity and decreased availability

- Crop switching, e.g., upland crops, pumpkin, peanuts, corn.
- Most farmers rely on drilled wells, typically 80 to 120 meters deep.
- Adjustment of irrigation methods
- Halting agricultural practices
  → Particularly farmers in lowland areas
- Rainwater harvesting is not a common practice
  → Concerns about water quality degradation due soil acidity

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Insights from the field: Financial and social realities influence technology implementation

Farmers recognize the potential of desalination technologies, but economic and community-related challenges need to be addressed first.

Social considerations

Household decision-making dynamics

Community consensus on resource use

Land ownership and share resources

Role of agricultural extension services

Insights from the field: Financial and social realities influence technology implementation

Farmers view the initial implementation of desalination technologies as a shared effort, with one treatment unit supplying desalinated water to multiple farms to reduce costs.

Ensuring long-term sustainability of desalination technologies

- Brine disposal

Typical: discharge in sea

Large scale installations

Maximum brine discharge limit

Dilute brine with other (waste) water streams

Evaporation ponds

Small scale installations

Deep well injection

Large and medium scale installations

Inland, brackish water

Produce salt

Zero Liquid Discharge

Economic benefits?

- Marine ecosystem damage
- Land degradation
- Brine leakage into freshwater aquifers, among others

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Ensuring long-term sustainability of desalination technologies

- Carbon footprint

Desalination powered by renewable vs. conventional energy sources.

- Groundwater depletion

Human-induced subsidence induced through aquifer compaction.

Desalination technologies as catalyst for water security

- In regions affected by salinity and water availability water treatment technologies are crucial in securing a reliable water supply for agriculture.

Important technology transfer and adaption to suit local conditions

- Collaborative approach to technology adoption

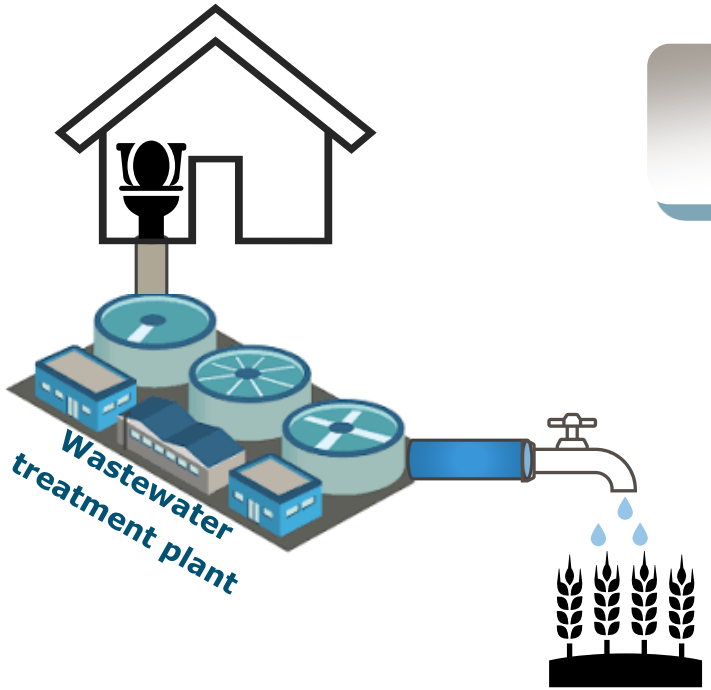
Government support, research innovations, and practical application come together

- It is important to balance technological solutions with understanding social realities and farmers-specific context.

Sustainable Practices in Dutch Farming– Securing water and reducing environmental impact in agriculture

Case studies

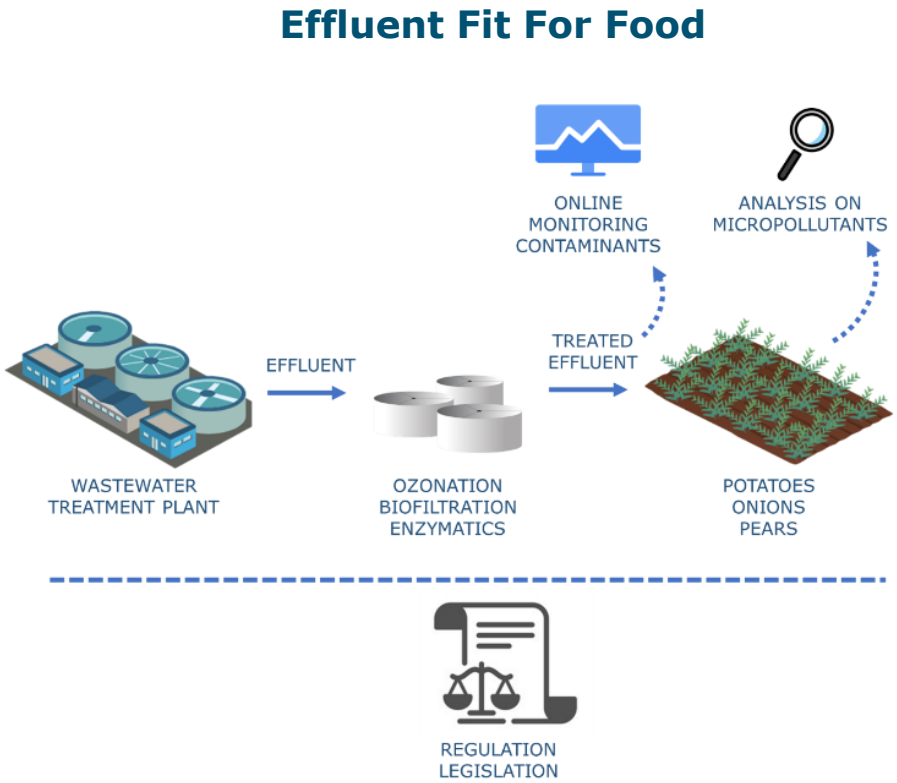
Harnessing treated wastewater for agricultural irrigation



Reduces dependency on freshwater resources

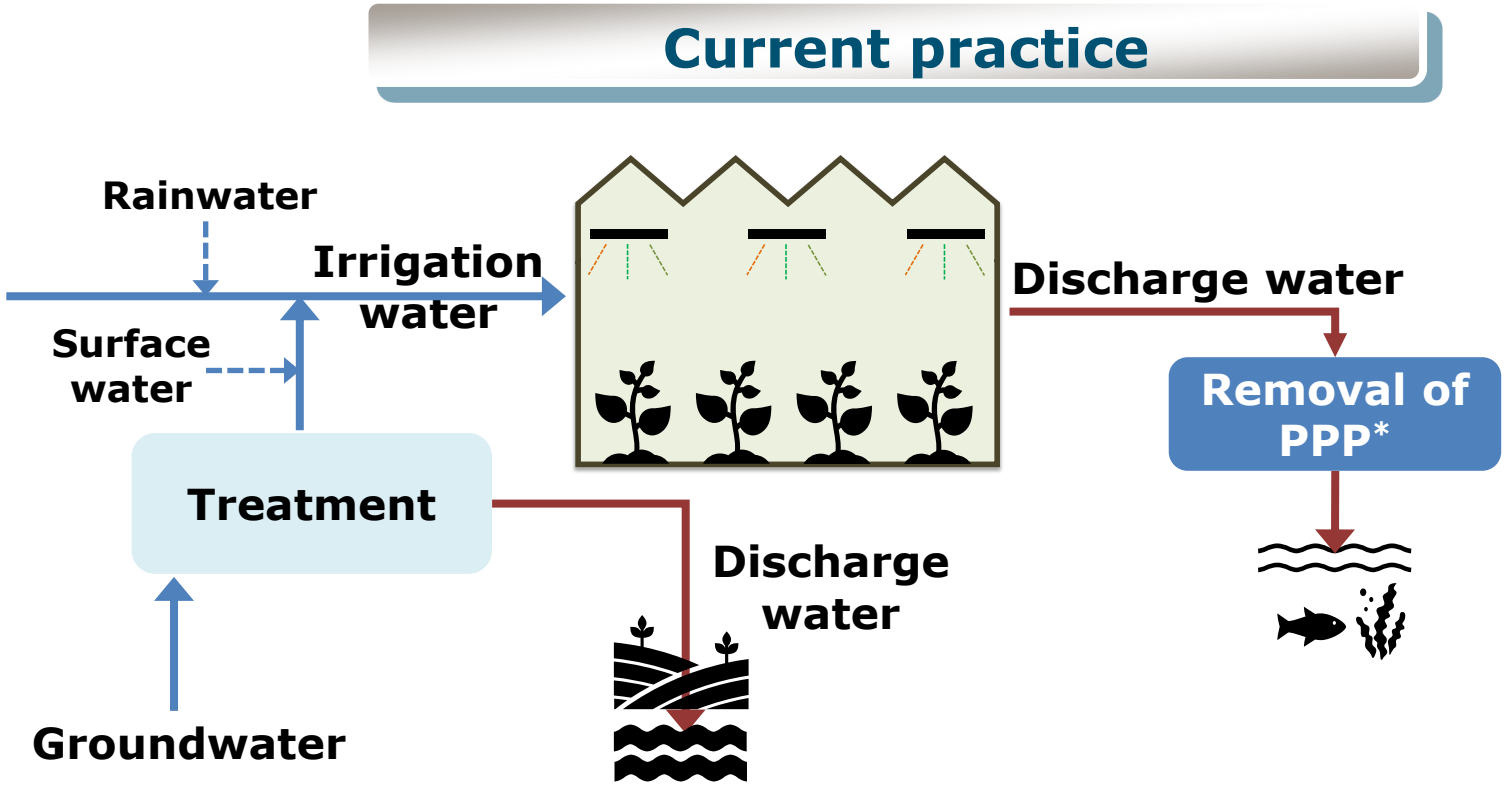
- Important to adhere to local and international standards for water quality
  - To ensure safety in agricultural use

Increasing availability of quality irrigation water- Dutch case study



- **Analysis of micropollutant uptake in crops**
- **Risks assessment of water reuse**
- **Identification of interventions (water treatment and monitoring)**
- **Review of regulations.**

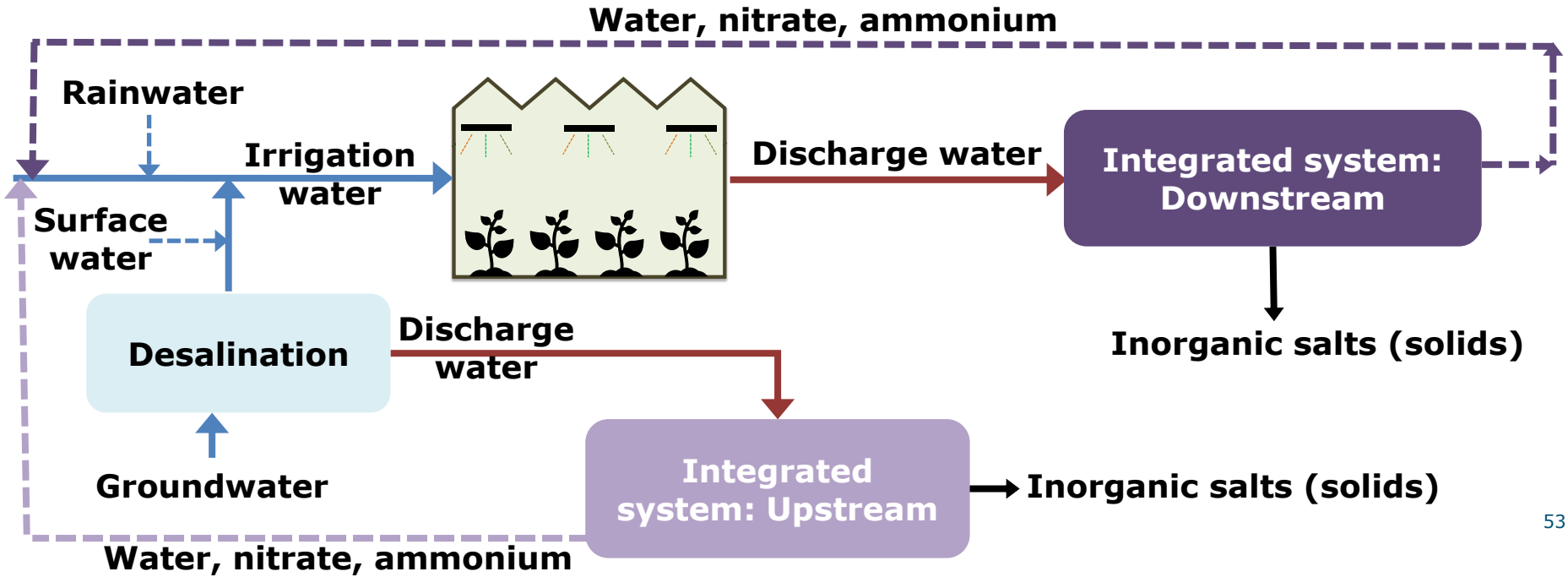
From desalination to discharge –Managing salinity in Dutch greenhouses



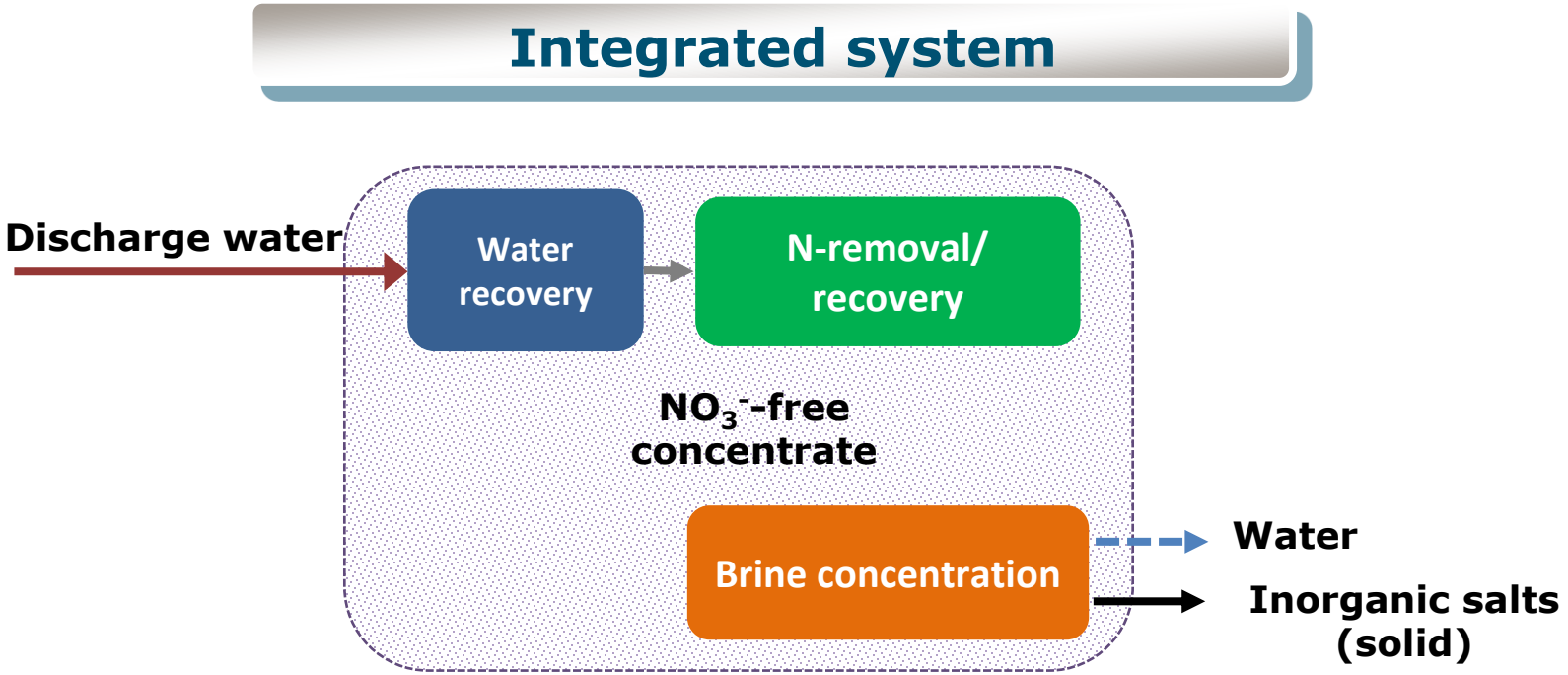
PPP: plant protection products

Integrating technologies to achieve minimum liquid discharge in greenhouses

Approach currently under study



Integrating technologies to achieve minimum liquid discharge in greenhouses



Can you identify any connections between the Food Systems Approach and the implementation of desalination technologies?

How do you think the implementation of desalination technologies might influence or be influenced by food system components?

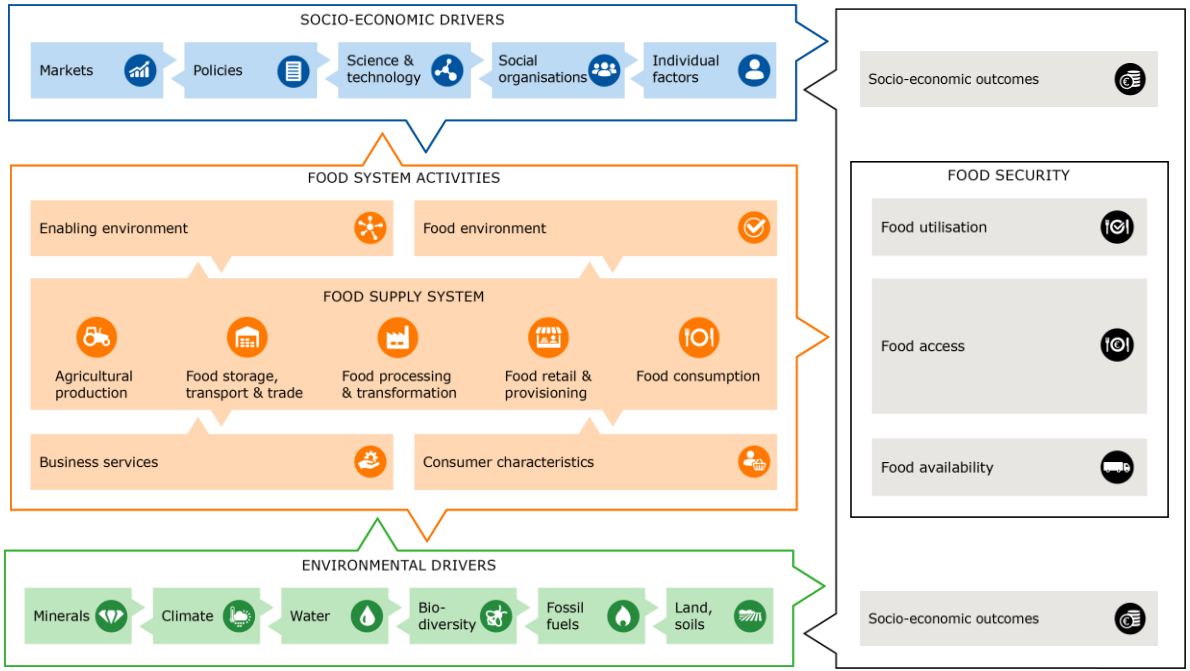
There is no single solution when it comes to tackling food problems

1. Food security: sufficient food for everyone

2. Ensuring a healthy diet

3. Fair distribution of costs and revenues

4. Sustainability: climate change, sustainable use of soil, water and other resources and biodiversity



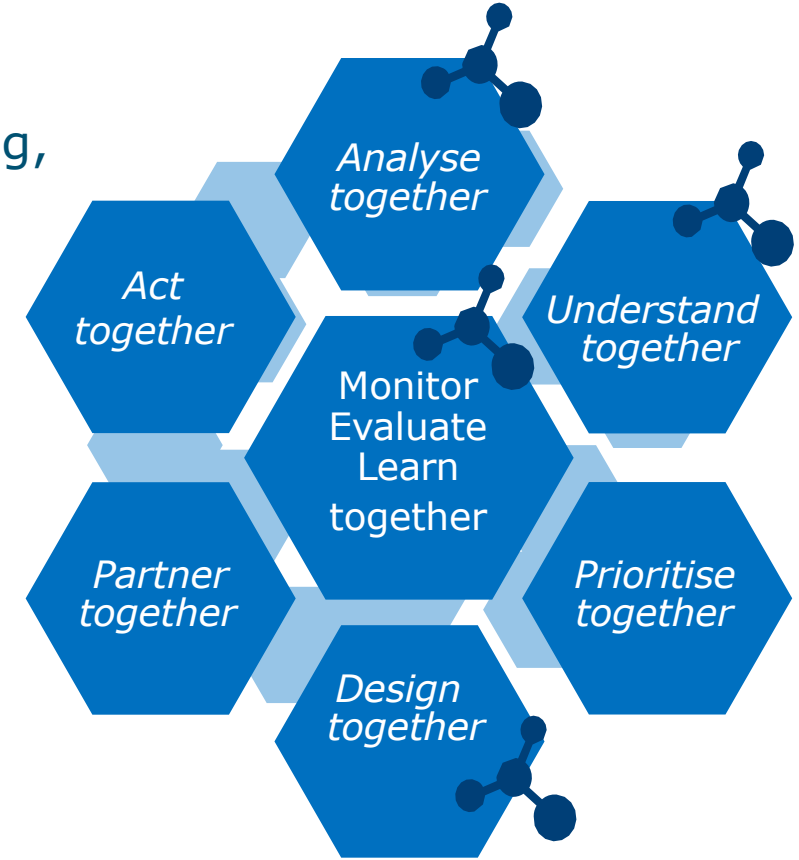
Role of research in Food Systems Transformation

Discuss with your neighbour:

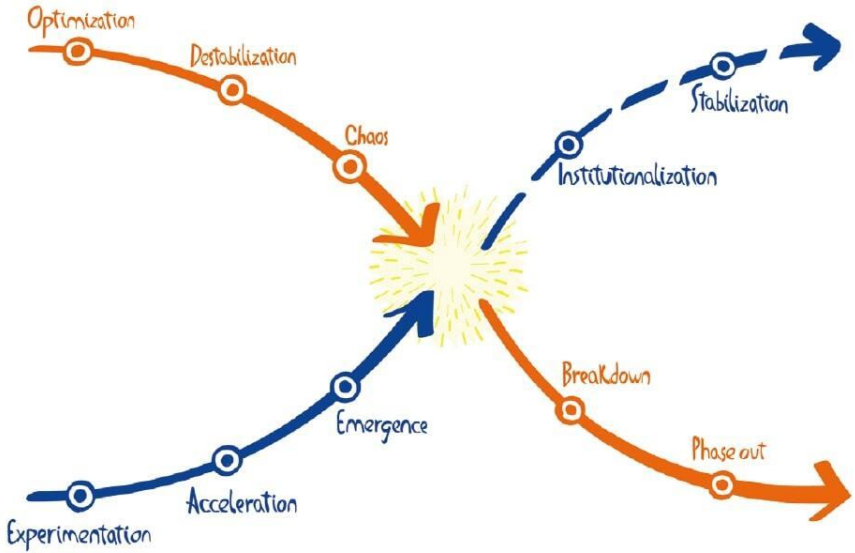
- Based on the presentations by Tossa & Tania, what do you think should be the role of research(ers) in Food Systems Transformation?

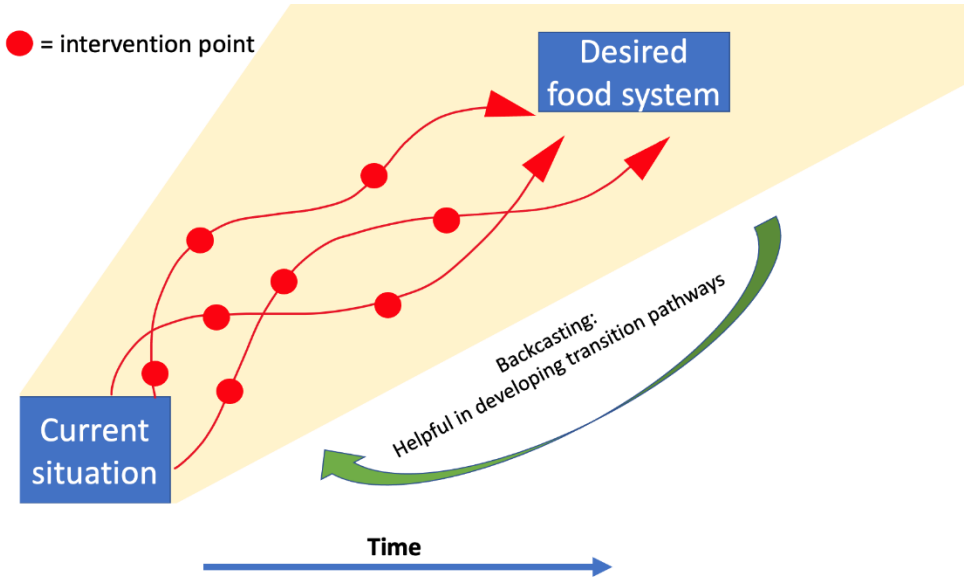
Facilitating Transition Pathways

- The role of researchers in food system transitions (engineering, observing, advising, facilitating)
- It takes time to study food system transition
- Manage expectations
- Bias of researchers
- Limitations of researchers
- Solutions proposed



Role of research(ers)





Generating knowledge to contribute to FST

Lessons learned

- **Complexity and uncertainty:** The challenge of embracing complexity, uncertainty, and a systems perspective as researchers with a more technical field of expertise.
- **Contextualisation and adaptive approach:** The need to take a iterative approach to problem analysis (revisit problem definition, evaluate & monitor progress, learn while doing), and adapt to local and changing circumstances. Build on in-country efforts and ongoing processes.
- **Collaboration with local partners:** The necessity of involving local stakeholders in problem definition and solution development. Building strong relationships and fostering trust, equal partnership, open dialogue, valuing different perspectives.
- **Reflexive learning:** the importance of being aware of your role as a researcher in the food system

Added value of using a Food System Approach

as technical researchers working on complex issues

- Create a common language to collaborate with different disciplines and sectors (stakeholders)
- Achieve a more complete understanding of the problem by including diverse perspectives
- Create common understanding of the current situation and problem definition
- Create common goals to work towards
- Generate knowledge that is relevant to local context
- Develop solutions and transition pathways that fit local realities (socio-economic aspect)
- Inform policies to align with and support solutions (create an enabling environment)
- Take into account potential trade-offs (eg negative environmental impacts)
- Complement and build on ongoing processes with science (research, experiments, data, knowledge, experience)

How can you use the FSA in your (future) career?

Discuss with your neighbour:

- What are your main insights about the food systems approach?
- Do you see the value in taking on a food systems approach?
- How can you use these insights in your own research/work?

Take-Home message

To safeguard water resources, support agricultural sustainability, and build resilient communities, we need:

- To understand salinity’s impacts
- To embrace innovative technologies
- To foster collaboration
- To understand social realities.