# Salinity Transition Approach for Progress - STAP

A stepwise integrated approach for action to address salinity-related issues

Deltares | WAGENINGEN UNIVERSITY & RESEARCH | The Salt Doctors | NWP Netherlands Water Partnership | NFP Netherlands Food Partnership

**Salinity Transition Approach for Progress - STAP**
A stepwise integrated approach for action to address salinity-related issues

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Cover figure: Irrigation practices for food production in Cuba, 2022 (Arjen de Vos - The Salt Doctors).

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# Contents



# Appendices

# 1 Introduction

**Problem description and relevance of the research**

Combining different fields of expertise is often challenging, and this is especially the case in newly emerging, interdisciplinary fields. The challenges related to salinization in soils, agriculture and water management are often not considered as linked processes, as a) solutions tend to be limited to either adapting agriculture (e.g., adapt crops and soil management) or water management (e.g., freshwater infiltration), and b) knowledge is held by different institutes, using different approaches that are difficult to combine. As a result, we miss out on opportunities for more optimal and sustainable solutions and measures. Therefore, there is great potential in bringing the worlds of agriculture, soil, and water management closer together. And preferably not only at field level, but also at landscape or (sub-)catchment level. Sometimes salinization can be limited or prevented by a more sustainable water use, sometimes agricultural practices such as soil management and variety choice need to be adapted, and usually both, and this needs to be based on a combination of different schools of thought. This requires an integrated approach and a focus on action, which also implies that different parties need to work together (i.e. private sector, knowledge sector, policy and decision makers) and different levels need to be linked.

This initiative aims to develop a framework for partners to collaborate in projects where agriculture and groundwater management are influenced by salinization. While water management ideally integrates the management of surface and groundwater, in this initiative we focus on groundwater because of its close relationship with the topics of (soil) salinization and agriculture. Additionally, focusing only on groundwater management allows for a well-defined water system scope.

**Scope and objective of the research project**

The initiative being small, we do not (yet) explore on 'food system' and 'water system' in the wider sense (including all the components of both systems and their interlinkages), as that would be beyond the scope of the current research, while we prefer to focus on mobilizing action and therefore we set clear boundaries on the components of the system that we are considering (groundwater, food security and soil salinization). For instance, the understanding of the link between water and food in the wider sense is often referred to as 'the nexus', and then also includes the aspect of energy: the water energy food nexus (Hoff, 2011). To include all aspects of the WEF nexus, is beyond the scope of this study. However, there is a need for a clear approach that can be followed to identify new solutions in regions where salinity is a (potential future) threat. A system-based approach is needed where the knowledge of water and food worlds can come together. Various system approaches exist, both for water and food, that are internationally used. For example, there is the Food Systems Approach (FSA) on which Wageningen University and Research works actively, and there is the Strategic Water System Planning (SWSP) framework that Deltares has developed.

> **Food Systems Approach** is an integrated approach to assess solutions for food security. It analyses 4 different goals: food production, nutrition and food safety, income (in)equality and resilience (e.g. climate change and biodiversity). Stakeholders from different organizations, sectors and disciplines can work together for solutions to complex problems.
>
> **Strategic Water System Planning** is a Framework for Achieving Sustainable, Resilient and Adaptive Management. The step-by-step and systems-based framework defines the integrated, comprehensive, and inclusive approach that needs to be followed in the planning exercise. It also facilitates communication with and among stakeholders during the study.
>
> More background information on the FSA and SWSP can be found in Appendix A.

Combining elements from the groundwater, soil and food perspective in a stepwise approach can provide guidance for future international projects where multiple partners from the Saline Water and Food Systems (SW&FS) partnership[1] can play a role, improving the effectiveness and impact. **We see this stepwise approach as a first step to formulate guidelines that can be used to identify actions in a region where salinity is a threat for water and/or food supply.** Initial work has been done in bringing together both food as well as water related planning processes (GWP, 2004; UN-Water and GWP, 2007; Haasnoot et al, 2013; Terwisscha van Scheltinga and Timmerman, 2020, Verhagen et al, 2022). With regard to management of groundwater, work has been done, which supports Funk et al. (2023). More background information on the FSA and SWSP can be found in Appendix A.

**Approach followed in this project**

Based on both frameworks and enriched with the specific experience of The Salt Doctors, Deltares and WENR on salinization studies, we designed an initial conceptual stepwise planning approach for actions addressing the salinization – groundwater – food security nexus: the Salinity Transition Approach for Progress (STAP). From now on the stepwise approach will be referred to as STAP. We aim for the approach to be applicable at various levels, from the field level to regional and national levels.

The value of a joint stepwise approach will become clearer by giving an example. Therefore, we presented our initial STAP in a general matter but applied it to a hypothetical case study in Bangladesh. All three organizations have knowledge of this country and are, or have been, involved in projects there. Exploring the applicability of the approach in a case study, makes the potential uptake of the application of the approach in practice more plausible. We invited different SW&FS partners for a workshop in late March 2023 to discuss and test the conceptual stepwise approach. During this workshop, the case study was presented as an example with the objective of evolving to a general framework that can be further tailored and applied to cases in other countries. With the input from different SW&FS partners during the workshop, the approach was further improved and tailored to the needs of the different partners. A summary of the workshop and gathered feedback can be found later in this document.

**Outline of the document**

In this initiative we made a start towards a stepwise integrated approach for action for partners to collaborate in projects where agriculture and groundwater management are influenced by salinization. The initial defined STAP can be found in Chapter 2. The outcomes of the workshop with SW&FS partners are described in Chapter 3. Chapter 4 describes the next steps that we envision. Since this initiative is a start towards a stepwise approach for integrated action, we want to implement and test it in case studies.

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[1] The Netherlands Food Partnership (NFP) and Netherlands Water Partnership (NWP) convene a multi-stakeholder partnership on Saline Water & Food Systems (SW&FS) to strengthen cooperation between the Dutch water and agrifood sectors to address the challenge of salinity in low and middle-income countries (LMICs). The partnership consists of knowledge institutes, diverse members of the business community including innovative SMEs, and experts operating locally. It is supported by the Ministry of Agriculture, Nature, and Food Quality.

# 2 Salinity Transition Approach for Progress

Combining the Food Systems Approach (FSA) and the Strategic Water Systems Planning framework (SWSP), in saline affected areas can be particularly useful in addressing the interdependent challenges of food and water security in transition processes. The thus developed stepwise approach STAP provides a framework for partners to collaborate in projects where agriculture and groundwater management are influenced by salinization.

Transition processes in general have an initiation period, a quickly changing period, and a later period, when new things get settled (Figure 1). In the beginning, a vision for the future is formulated, though the future is uncertain, and the situation often complex. For example, the adjustment of the crop to higher soil salinity levels through plant breeding, and crop choice, as well as adjustment of the circumstances (earlier planting, adjusted water application, and soil management) can all be transition-pathways towards a more sustainable future. Who is involved in initiating the change and sustaining it, as well as how does a sustainable future look like, are important question in the process.

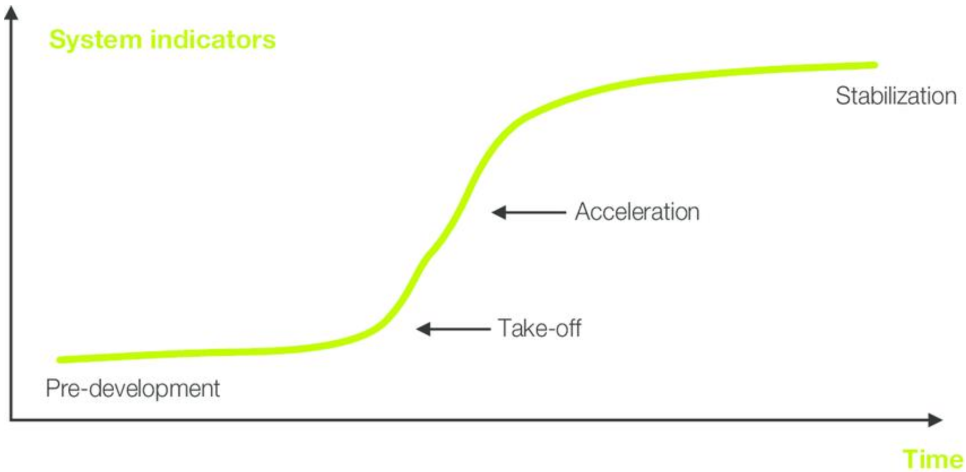



*Figure 1 Transition S-curve as used in Terwisscha van Scheltinga and Timmerman, 2020*

STAP can be visualised as a process by a circle (Figure 2), where one starts at step one (the inception phase) and after completion of the circle is back at the inception phase. To assist in engaging together with various stakeholders in an action-oriented planning process, STAP has been prepared. The steps to go through are:

1. Inception;
2. Analyze;
3. Understand;
4. Explore;
5. Prepare;
6. Implement together

Meanwhile all the time reflection and joint learning are part of the process.

The circle shape is intentionally as the proposed structured planning steps are a continuous and iterative process; each time the cycle is performed a more refined and in-depth approach to tackle the problem can be achieved and transition can take place. Besides, while this framework is presented as a simple one-directional flow of activities, in reality there might be many feed-back loops involved in the process. This is especially the case since in principle, STAP focusses on practical implementation, and therefore step (5) needs to be achieved quickly, only after that, the continuous cycling through STAP can improve the outcomes of the project. As such, the first four steps are sometimes treated in depth, and sometimes shallower, to be later refined.

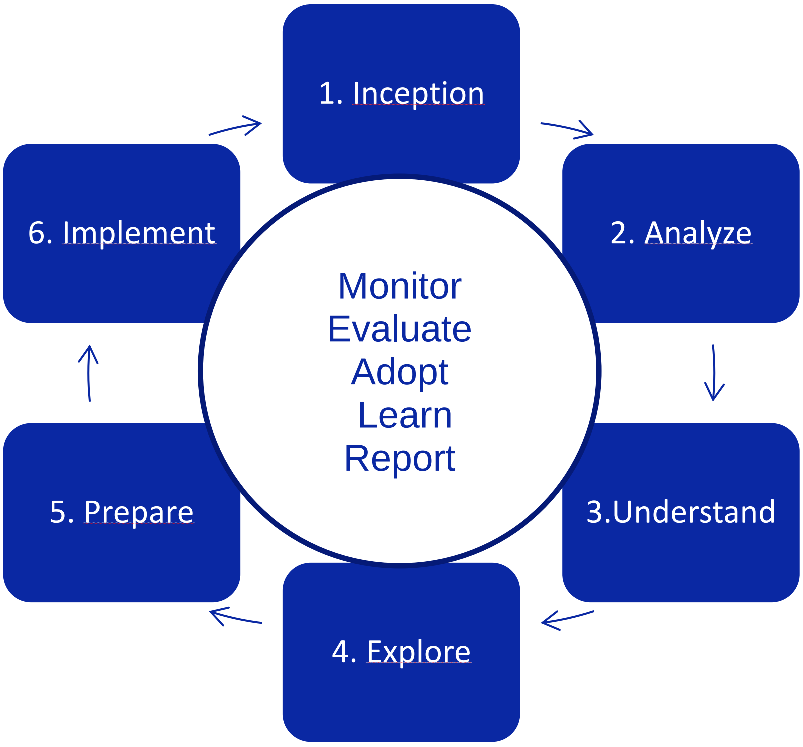



*Figure 2 A stepwise approach in developing a framework for partners to collaborate in projects where agriculture and water management are influenced by salinization.*

In addition, every step of the way may change the perceived problems and solutions, so flexibility and feedback loops might be required (it is not a one-dimensional process) to develop the strategy that best fits the situation.

1) Inception: identifies the subject of the analysis (what is to be analyzed and under what conditions), the objectives (the desired outcome of the analysis) and constraints (its limitations). In this phase stakeholders (e.g., government, institutions, water boards, farmers, nature conservations) and investors are identified and their engagement in the decision-making process begins.

   Specific aspects related to groundwater, soil, food, and salinization:
   - What is the problem? Since when does it occur? Where? What is the magnitude? What is the expected magnitude for (near) future?
     - What are the groundwater and soil salinity levels in the study area or region?
     - How is food production affected by salinity?
     - How is the situation expected to change?

- What are the current practices regarding water and soil management, and food production?
  - Are crops irrigated with (saline) groundwater? When? what are the concentrations of the irrigation water?
  - What is the water use under current conditions?
  - What action, if any, is undertaken or already scheduled to mitigate or adapt to soil and/or water salinization?

- How does the water and food system look like? What are the elements of the system and what are their interlinkages (aquifer, irrigation canals, drainage, fields, weirs, wetlands, crops, rivers, soil type, value chain,etc.)?
  - What are groundwater specific elements for this location? is there capillary rise and leads this to an increase in salinity levels of the rootzone? When does this occur and at which stage of the crop?
  - Which elements of salinity relate to crops? What type of salinization process is occurring? Is there a variation in the salinity level, and if so, how does it relate to groundwater availability and crop stage?

- What should be the objective of the actions to be taken, from different stakeholders point of view? Or is a medium/long-term plan needed?
  - What would be the desired productivity? what would be ideal groundwater levels throughout the year? And salt concentration in the groundwater and the soil?
- What are the governance and policy instruments to be considered in the study? How do they condition the eventual implementation of actions?
  - Are farmers/and or policy makers aware of the salinity problems and how do they see actions?

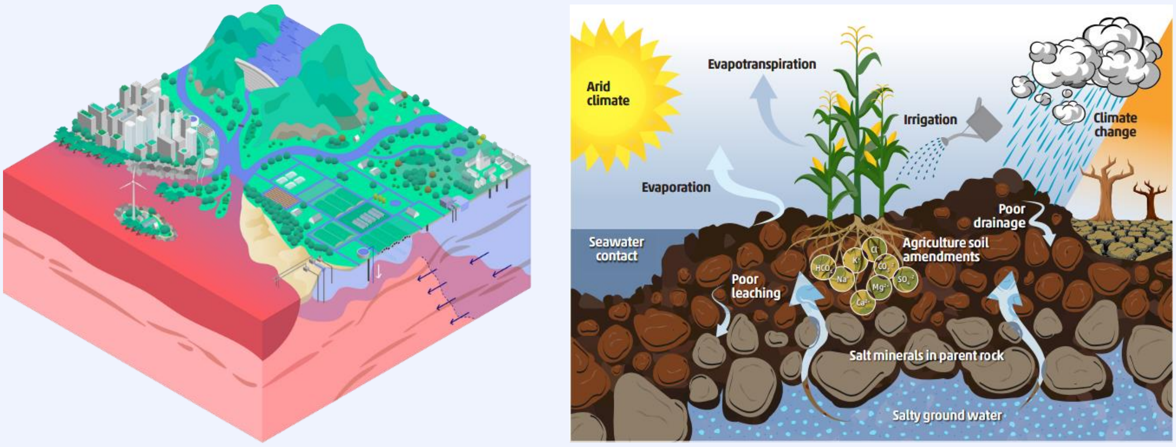
2) Analysis: analysis of present and future food & water system situations. Major activities in this phase typically include data collection and data analysis and sometimes modeling. Relevant data that needs to be collected depends on the scale the project is looking at. Models are often used to describe present and future system characteristics in a quantitative way. These characteristics can be expressed in multiple economic, environmental, and/or social indicators and indices, to name a few. It is key to analyze the system situations from different perspectives and at the appropriate levels (spatially and time-oriented). To provide insight into uncertain futures, scenarios should be developed that describe the future boundary conditions for the system. Please note that easily the list to analyze is becoming longer, while that may delay coming to action. Careful balancing of the two is required. Some issues, especially ‘future conditions’ are hard to predict. Learning from longer term planning in water management (e.g., delta plans) shows that an approach making some kind of vision first, and filling in details later, can be very helpful. The level of detail required, is also depending on the type of decision related to it.

   Specific aspects related to groundwater, food, and salinization:
   a. What are relevant scenarios to consider in terms of climate, and socio-economic changes?
   b. What are the business operation opportunities for the food sector today and in the future?
   c. What is the demand for crops now and in the future? How may the demand change, and based on what? Which crops are traditionally farmed? Are there any crops that they wish they could produce but currently not growing? Why?
   d. What will be the water use under future (physical / socio-economic) conditions?

e. What is the freshwater availability today and in the future?
f. What are the current required and acting water and soil salinity levels? How do they fluctuate throughout the year? How will these evolve under different climate and water/soil/farming management scenarios?
g. What are the causes of salinization and freshwater shortages?
h. On national scale, is there enough water to ensure food security now and in the future?
i. What technology is available now to increase freshwater supply?
j. What are the current farming practices, perceived limitations and possibilities?

3) Understanding: Enhance the understanding of the interlinkages between the food, soil & water systems, and their various characteristics. Additionally, the cause of salinization must be understood (Figure 3) to be able to formulate appropriate action. Salinization is usually categorized as either primary (i.e., natural) salinization, or secondary (i.e., man-made) salinization. Either of these causes require different action, and especially in the case of secondary salinization, proper training of the farmer may be a large part of the solution. However, dealing adequately with salinization, no matter the cause, always requires in integration of crop-water-soil. These three components also affect each other, a process that needs to be understood (Figure 4).

In this phase a common 'picture' of the relevant components needs to be sketched to find the gap between the freshwater and food demand and availability in the current and future states. In this phase the researchers together with the stakeholders are looking at the feedback loops and trade-offs between water, soil, food and salinity. It is important to understand where critical thresholds of indicators and decision moments are within these pathways. This will force the implementors of the project to think about which aspect of salinization they will focus on the most: will the focus be on water salinity or crop yield or salinity in soil or multiple of these and their interaction. Understanding the situation, available resources and exact wishes and demands also steer the formulation of potential solutions, and naturally evolves into the next step (Figure 4).




**Source:** Salinisation the slow disaster (Deltares) **Source:** Global map of salt affected soils (FAO)

*Figure 3 Infographic of salinization processes in Delta's on national scale (left) and interlinkages between salinity, soil, food & water systems on farmer scale (right).*

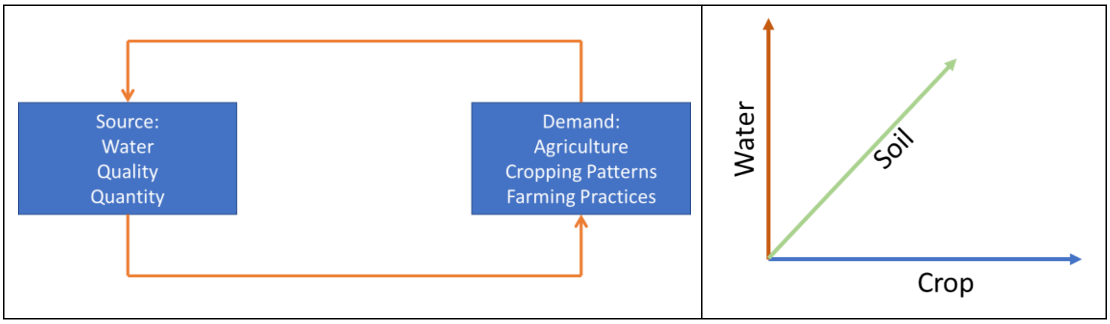



*Figure 4 Interaction between water and food (left), focus on water or crop or soil (right)*

4) Explore: explore measures that can be taken to fill the gap between the freshwater availability and water requirements for food security in the current and future states and how to deal with future increased salinization risks. Information needs to be gathered on the technical, social, economic and operational aspects of these measures. It is important to explore which measures are most suitable in each scenario sketched in step 2. It could be that the suitability of a measure differs in time and space between different scenarios.

Possible measures are:

a. Conservation and efficiency measures
b. Water reuse and recycling
c. Managed Aquifer Recharge
d. Install drainage
e. Salt tolerant seeds for crops and vegetables
f. Improved soil management
g. Improved farming methods (i.e., crop rotation, increasing soil organic matter, using mulch etc.)
h. Create awareness on water usage and shortages aiming at reducing water demand
i. Adaptive and nutritious diet in the future
j. Low cost, energy efficient and locally made technologies for desalination

Once the potential measures have been identified, a selection and prioritization of the preferred measure or measures is needed.

5) Prepare: An implementation plan will be developed which provides details on the necessary steps to implement the measure or set of measures. The plan should include what will be done, by whom, when, and how it will be financed, etc. Additional work may be needed before decisions are made, including conducting feasibility and design studies and environmental and social impact assessments (ESIA). Promotion of the selected strategy (set of measures) is needed to gain public acceptance of the proposed measures. Finally, institutional arrangements will have to be made to ensure smooth implementation.

6) Implement: during the implementation phase the actual implementation of the project and the measures that have been selected will take place. Continuous monitoring and evaluation are needed to accommodate the transition process and acknowledge socio-economic dynamics and environmental changes during the implementation.

Learning is key in this stepwise approach. It is therefore important that every step is evaluated, and progress is monitored. This will allow for correction, stimulation or cease of activities when needed.

a. Evaluate at each step: what went well, what problems had to be overcome?
b. Adjustment: monitoring during the process
c. It is also important that the end of each step is marked with a go/no-go moment in which decision makers are involved. Is there commitment for the outcome of the step? What are points of attentions for the next step?

The above steps can be taken at different spatial scales, such as local/community scale or regional/national scale. Based on the level of the action foreseen, the process will look very different – both in time as well as in scale: a river basin scale action may take more time than a field level scale action. Additionally, the resources that can be used to analyze the situation will be very different, both from a water systems perspective, as well as from a food systems perspective.

# 3 Workshop with SW&FS partners

In areas where salinity is present and groundwater is used for crop production (potentially leading to salt affected soils), policy makers need to make decisions on investments addressing future food demands. How to do this, while taking both water and food systems into account?

We use a hypothetical situation in Bangladesh as a testcase for the Salinity Transition Approach for Progress (STAP), to assist us in making steps and interlinkages between food, water, and salinity clear. The overall objective of following the stepwise approach is to identify possibilities for sustainable food production and sustainable groundwater use.

## 3.1 Description workshop

On the 28th of March 2023 11 experts came together at the office of Deltares in Utrecht. The goal of the workshop was to test the developed stepwise approach with SW&FS partners coming from different fields of expertise. We used STAP in a hypothetical case study which was explained to two subgroups: one was asked to apply the approach on a national scale, while the other group was asked to apply it on a farm scale. The following experts attended this workshop:

- Kate Negacz (VU & INSAS)
- Arjen de Vries (Acacia Water)
- Timo Cober (LNV)
- Gualbert Oude Essink (UU & Deltares)
- Otto de Keizer (Deltares)
- Catharien Terwisscha van Scheltinga (WENR)
- Feroz Islam (WENR)
- Bas Bruning (The Salt Doctors)
- Marta Faneca Sanchez (Deltares)
- Ilja America-van den Heuvel (Deltares)
- Judit Snethlage (WENR) attended online

Below are some pictures to give an impression of the workshop.

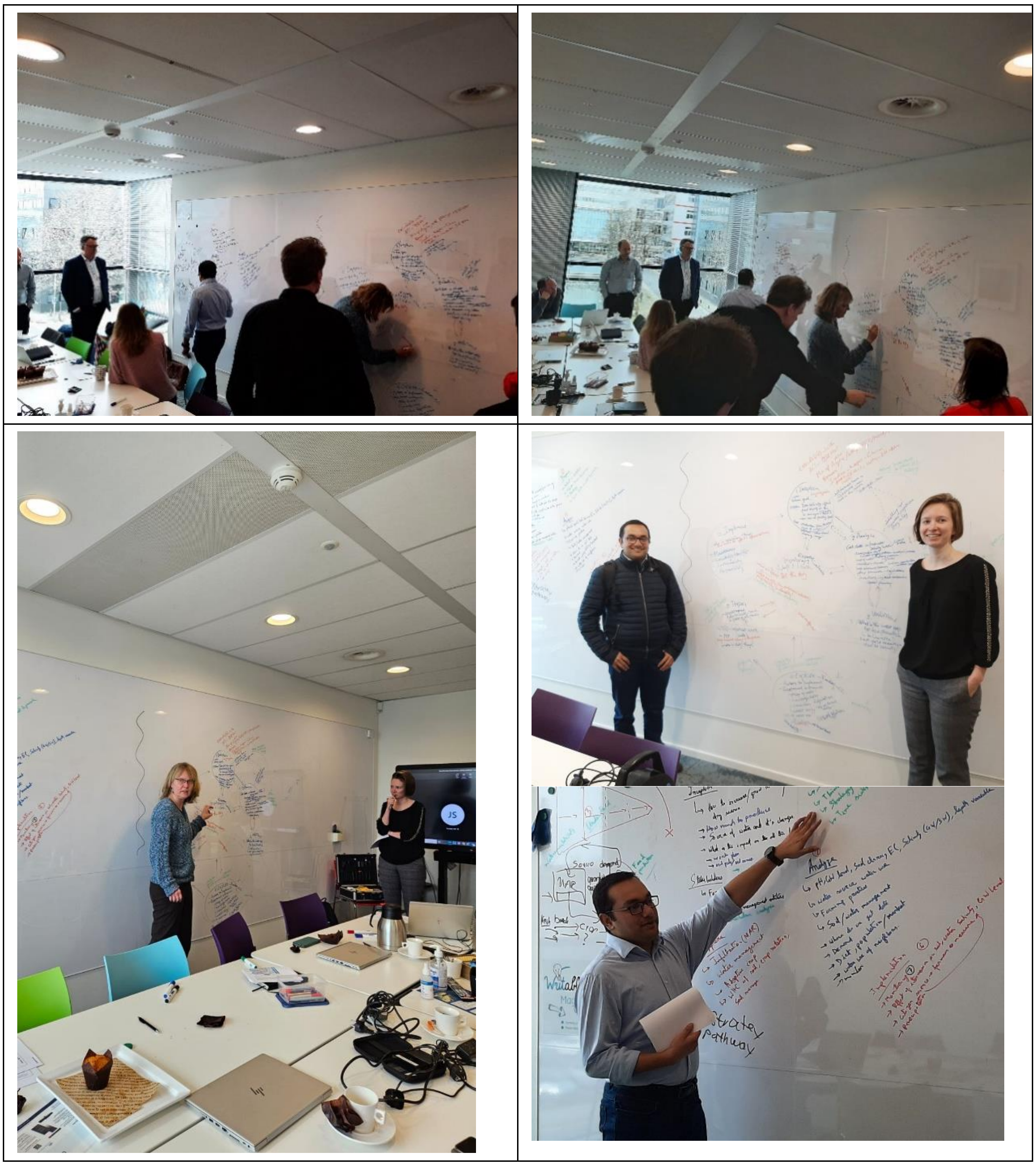


*Figure 5 Impressions of the workshop 28-03-2023*

## 3.2 Description of case study

The Coastal region in Bangladesh is characterized by highly seasonal precipitation patterns, i.e., rainfall is concentrated during the monsoon/rainy season. During this time, most farmers produce rice. As the rainy season ends, the outflow of the rivers to the sea diminishes, up to the point where the tidal flow is more saline and seawater intrusion becomes a dominant factor, which in turn salinizes groundwater and river flows. When slightly saline, this water is still used for irrigation, leading to soil salinity increase and affecting crop yields. In the rainy season, the salinity is washed out to some extent, and salinity levels drop. In short, the region suffers annually from salinization, but surface water is also reset every year to freshwater conditions. The concern is that salinity levels are increasing, due to both increased upstream water use (decreased river flow) and sea level rise pushing saltwater intrusion more upstream. For crops, increased temperature and irregular rainfall also increase demand for groundwater.

The hypothetical study area is in a coastal zone close to an estuary. There is (mostly seasonal) salinity in the area and it is different in surface water, groundwater and in the soil. Freshwater flows in the river, soil salinity and salinity in groundwater and surface water vary seasonally (see Figure 6). It is highest during the end of the dry season and lowest during the wet season.

The choices farmers make regarding the cropping pattern of the area are driven by the experience of farmers, their means, transport possibilities, food demand, cultural aspects, marketing opportunities, water management in the area, technology available and availability of fresh water (rainwater, surface water and groundwater) for irrigation. Farmers of the case study area produce crops for domestic consumption as well as for national and international markets. They produce vegetables and high profitable crops as well. The choice of crops is governed by the demand for food, market opportunities, soil characteristics, water availability in terms of water quantity and water quality, and traditional and cultural aspects.

Guidelines for such a case study area should be prepared considering food system and integrated water resource management at different scales (field scale and larger, Figure 7) and different timeframes (seasonally and yearly Figure 6).

At different spatial scales such as local/community level and regional/national level the market opportunities, transport, food demand, water availability and management are different. At the local level, farmers may focus on agricultural production for household usage and demand in local markets and at a regional/national scale this might depend on the policy and focus of regional/national government entities. Transportation, infrastructure, and urbanization play an important role at both scales. Water is managed at a local scale, for example in a polder or at a field, and at the regional/national scale through large scale projects on water management such as different irrigation projects or prioritizing/promoting efficient water use practices.

With climate change, sea level rise, anthropogenic changes such as withdrawal of fresh water from upstream, construction of polders, and over exploitation of groundwater, salinity is projected to increase in the case study area in the future. Urbanization of the coastal areas and deltas are projected to increase in the future with more people living in coastal regions. With urbanization the food demand for these areas will change and future infrastructure development will impact the market opportunities. All these will impact the cropping pattern in the future as well as the water demand. Increasing salinity and withdrawal of water from upstream might result in freshwater deficiency. At the field scale the water is used by communities or farmers for agricultural production but to assess the groundwater resources, larger scales (i.e. aquifer level) need to be analyzed. Similarly, national policy or market demand governs the food demand while agricultural commodities are produced at the field scale by the communities and farmers.

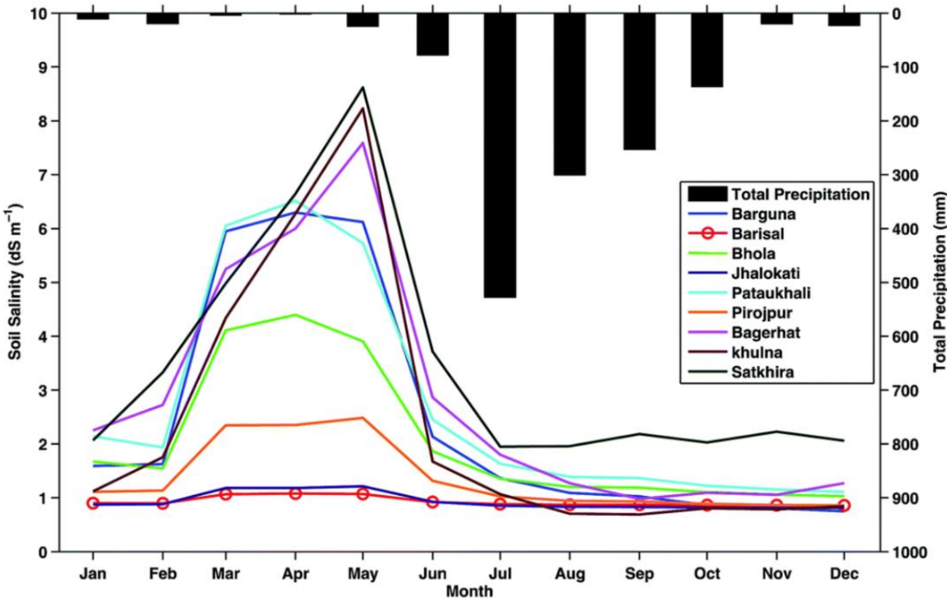



*Figure 6 Example of seasonal variation of soil salinity (Clarke et al., 2015)*

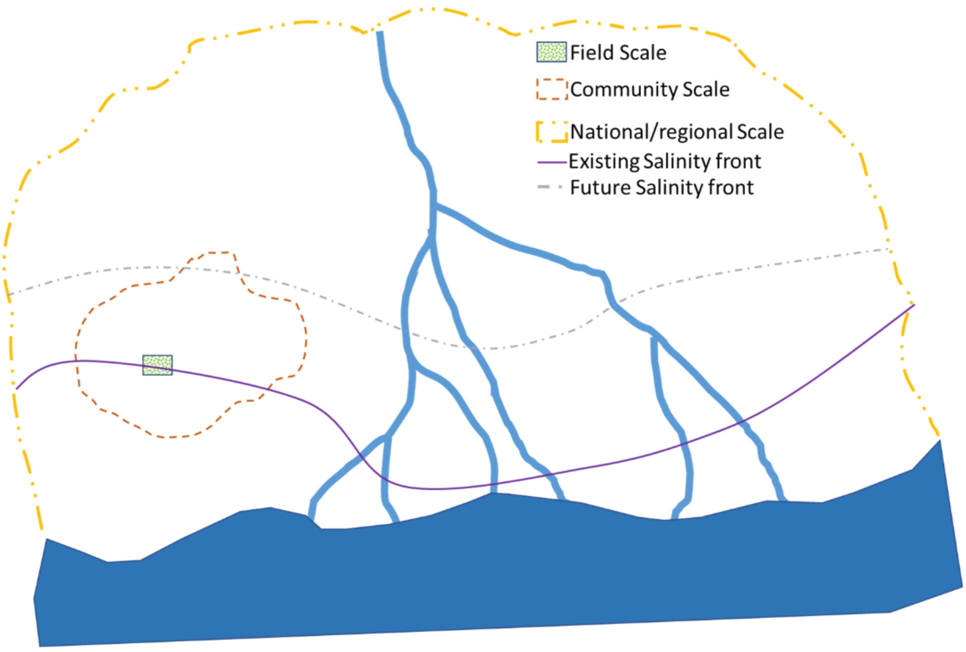



*Figure 7 Illustration of case study (hypothetical) and different spatial scales*

## 3.3 Feedback on STAP

The workshop was intended to get feedback from other interested partners on the framework that has been developed by the project team. The text below summarizes the feedback received for every step of the approach, first for the regional scale and then for the local scale, representing the two different groups of participants in the workshop. A more detailed description of the outcomes of the workshop can be found in the Minutes of Meeting (see appendix B).

### 3.3.1 National scale

In the group that applied our approach on a national scale the following people were present:

- Kate Negacz (VU & INSAS)
- Timo Cober (LNV)
- Gualbert Oude Essink (UU & Deltares)
- Catharien Terwisscha van Scheltinga (WENR)
- Ilja America-van den Heuvel (Deltares)

In this group, Ilja and Catharien led the discussion going through the steps as shown in Figure 2. As above, we first describe some general remarks and then describe specific remarks for each step.

General remarks:

- Reasonable easy to fill in steps 1 till 4 from a more general perspective.
- It is difficult to add specifics related to salinity when reflecting from a national scale.
- It is important to take investors/funders along in the process. Steps 5 and 6 are more likely to be successful.
- It is important to draw pathways within the process, using scenario analysis.
- Communicating scenarios and pathways to the world following a story telling approach, contributes to bring stakeholders along and gain their trust.
- Several iterations are required to deduce the most suitable plan.

Different take home messages were written down in Table 1 for each step in the approach.

*Table 1 Take home messages from national perspective in workshop*

| *Step in STAP* | *Take home message* |
|---|---|
| Inception | Take investors & other stakeholders along. |
| Analyze | Vision scenarios & incorporate envisaged changes |
| Understand | You should try to understand where critical tipping points / decision points are within the envisioned pathways. |
| Explore | Check effectiveness of measures (against indicators related to envisioned goal / costs / livelihood) & form a set of preferred pathways that could first be tested on smaller scale (pilot) for the second round of STAP. |
| Prepare | In order to make this step relevant it is important to bring investors along in the process at an early stage, i.e., already from the inception step. |
| Implement | In order to make this step relevant it is important to bring investors along in the process at an early stage, i.e., already from the inception step. |
| Monitor & Evaluate & Adopt & Learn | This step should be renamed to “Monitor & Evaluate & Adopt & Learn & Report”.<br>Additionally, the story should be told to bring people along and gain their trust. This should start from step 1 where stakeholders and investors needed to be taken along to envisioned pathways. |

### 3.3.2 Farm level

In the group applying our stepwise approach to the hypothetical case study at a regional scale were the following people:

- Arjen de Vries (Acacia Water)
- Otto de Keizer (Deltares)
- Bas Bruning (The Salt Doctors)
- Feroz Islam (WENR)
- Marta Faneca Sanchez (Deltares)

A lively discussion guided by Feroz and Marta developed while the group went through the steps. It was concluded that naming all the specific types of questions that one would want to have an answer to at the start of any project was too much and of little added value. The added value was to try and identify questions and steps that were unique to this stepwise approach which is specifically aimed at cases with a focus on groundwater, food and salinity.
General remarks:

- Several iterations are required to identify the most suitable plan.
- Sometimes there are actions that come in several steps. For example, monitoring in the field should be started in step 2 (analyzing) to have a base line and should be reassessed or adapted in step 6 (implementation) to monitor the performance of the measures.
- To understand how the plan can be financed and implemented, a stakeholder analysis is required.
- There are overlaps between the food system and integrated water resource management approach and both need to be considered as linked processes where both framework can enrich each other.

The circular design of the stepwise approach suggests that it can be completed several times during one project, getting more and more detail along the way and in that way refining the approach and solutions more and more to the specific details of the particular case.

### 3.3.3 Reflections

- Going through the steps helped to ensure interaction between experts with various backgrounds. This helps to get more integrated knowledge, but that does not yet ensure that action will be taken more quickly. During the workshop we found that different terminology is used between experts with different backgrounds. We advise to act on finding the common objective and reserve time to understand each other in order to speak the same 'language'.
- To discuss a case at the local level and at the national level brings different aspects to the table. The levels are interlinked. Not only for physical aspects, but also at policy level there are differences and there is interlinkage. It was felt to be useful to acknowledge and discuss this.
- The workshop with SW&FS partners woke some points of attention, namely:
    - Stakeholder involvement and ownership are key when it comes to implementing the plan. Involving stakeholder (and investors) from the beginning is one of the most important actions for successful implementation.
    - A plan can only be implemented when enabling conditions are present, specifically the existence of clear policies and laws. If there is an absence of these conditions, the strategic plan should include measures which allow for their creation, i.e., the development of new policies, laws, and institutions, as well as capacity building of responsible organizations.
    - Confirming that the plan is realistic and can be translated into implementable projects that are financially feasible.

# 4 The next steps

This initiative has been a fruitful exercise for all the SW&FS partners that participated in the workshop. It was insightful to see how people from different backgrounds emphasize different aspects of the case study and suggest different types of interventions. Additionally, participants indicated that the workshop was a good networking event for all.

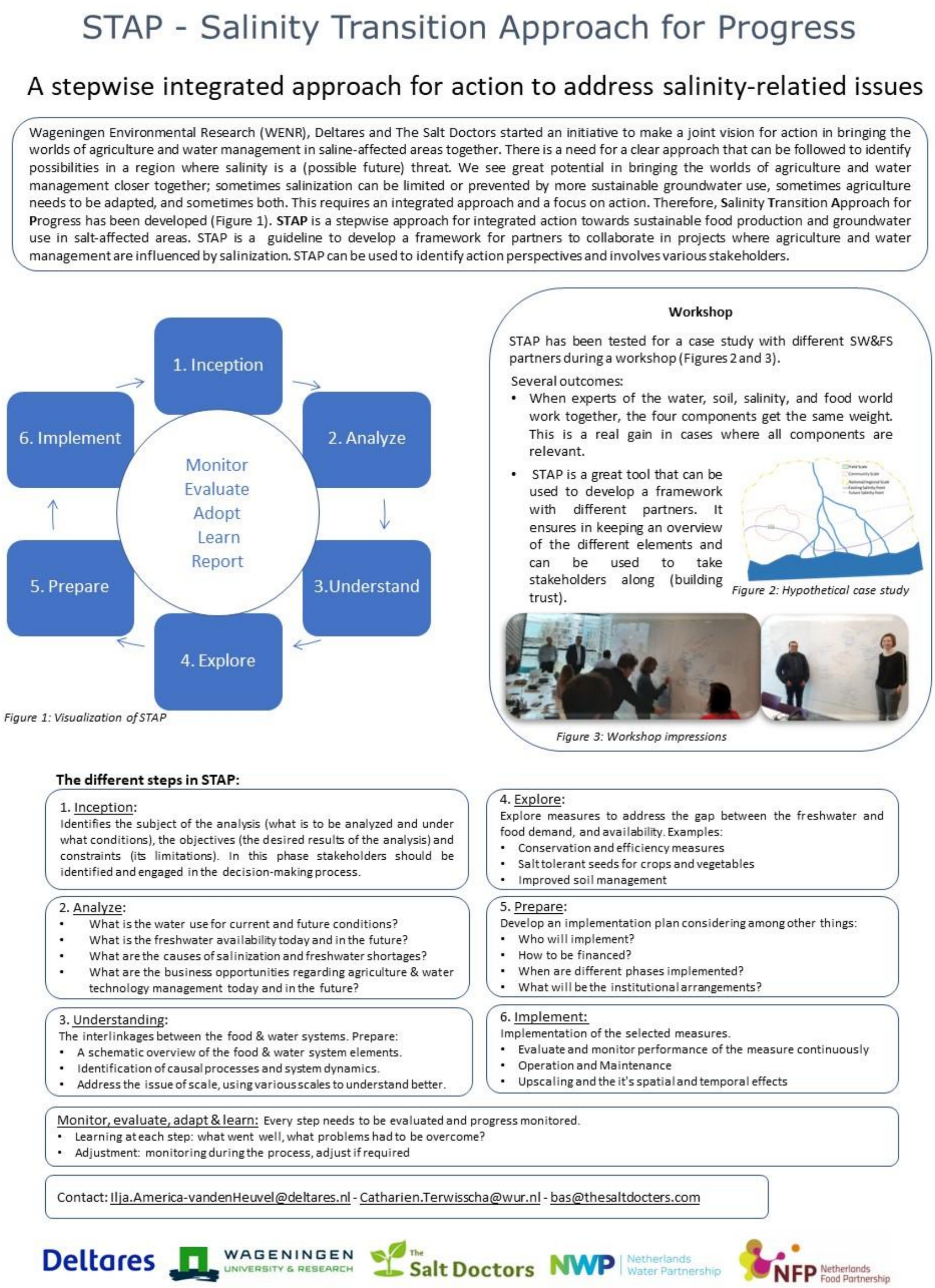
The next logical step is to start implementing STAP. There are two options for this: first, individual organizations within the partnership can apply STAP to running projects and see if it functions satisfactorily. This is possible for the three partnership partners that have worked on this approach: Deltares, WENR and The Salt Doctors, and would allow us to document learning lessons along the way, that can then feed back into the approach, improving it as we continue with our projects. By using STAP in big consortia projects, multiple organizations will get a means to work together on complex problems, using the Salinity Transition Approach.

Applying STAP in running projects has the advantage that we can work based on running projects. However, this does now allow us to apply STAP from the start and will therefore not allow us to fully test the approach. For research purposes we would prefer to test the approach on a real-life case from step 1 up till step 6 and report on the practical application in real life setting. We think, the approach can be a starting point for a new project. To this end, a consortium of the partnership can apply for funding, for a project that includes practical field activities which allow us to test the stepwise approach from step one. This would be the best test for our newly developed stepwise approach.

Another activity to follow up on this exercise is to share STAP with a wider audience. One opportunity that we've already taken is to present our approach at the INSAS (International Network of Salt-Affected Soils) conference, held on 22-26 of May 2023. This was an excellent occasion to share this approach. As the name suggests, the audience at that conference closely matched our target audience. This has led to new contacts, which we are currently following up. Another conference where we could present STAP is the Global Food Security Conference in Leuven, to be hold on 9-12 of April 2024. We will assess if there are other suitable conferences that could also serve for further dissemination of our approach and engagement with stakeholders.

We have produced a poster (Figure 8)  that summarizes the findings described in this report. This also serves to disseminate STAP to a broader audience. We will start sharing the obtained lessons so that other organizations can start working with STAP.

To conclude, these are some of the ways to follow up on the shared efforts to develop STAP. Seeing the positive feedback received during this initiative and on STAP, we encourage SW&FS partners to apply STAP and share their suggestions to bring it to the next level.



# STAP - Salinity Transition Approach for Progress

## A stepwise integrated approach for action to address salinity-relatied issues

Wageningen Environmental Research (WENR), Deltares and The Salt Doctors started an initiative to make a joint vision for action in bringing the worlds of agriculture and water management in saline-affected areas together. There is a need for a clear approach that can be followed to identify possibilities in a region where salinity is a (possible future) threat. We see great potential in bringing the worlds of agriculture and water management closer together; sometimes salinization can be limited or prevented by more sustainable groundwater use, sometimes agriculture needs to be adapted, and sometimes both. This requires an integrated approach and a focus on action. Therefore, **S**alinity **T**ransition **A**pproach for **P**rogress has been developed (Figure 1). **STAP** is a stepwise approach for integrated action towards sustainable food production and groundwater use in salt-affected areas. STAP is a guideline to develop a framework for partners to collaborate in projects where agriculture and water management are influenced by salinization. STAP can be used to identify action perspectives and involves various stakeholders.



*Figure 1: Visualization of STAP*

**Workshop**

STAP has been tested for a case study with different SW&FS partners during a workshop (Figures 2 and 3).

Several outcomes:
- When experts of the water, soil, salinity, and food world work together, the four components get the same weight. This is a real gain in cases where all components are relevant.
- STAP is a great tool that can be used to develop a framework with different partners. It ensures in keeping an overview of the different elements and can be used to take stakeholders along (building trust).

*Figure 2: Hypothetical case study*

*Figure 3: Workshop impressions*

**The different steps in STAP:**

1. Inception:
Identifies the subject of the analysis (what is to be analyzed and under what conditions), the objectives (the desired results of the analysis) and constraints (its limitations). In this phase stakeholders should be identified and engaged in the decision-making process.

2. Analyze:
- What is the water use for current and future conditions?
- What is the freshwater availability today and in the future?
- What are the causes of salinization and freshwater shortages?
- What are the business opportunities regarding agriculture & water technology management today and in the future?

3. Understanding:
The interlinkages between the food & water systems. Prepare:
- A schematic overview of the food & water system elements.
- Identification of causal processes and system dynamics.
- Address the issue of scale, using various scales to understand better.

4. Explore:
Explore measures to address the gap between the freshwater and food demand, and availability. Examples:
- Conservation and efficiency measures
- Salt tolerant seeds for crops and vegetables
- Improved soil management

5. Prepare:
Develop an implementation plan considering among other things:
- Who will implement?
- How to be financed?
- When are different phases implemented?
- What will be the institutional arrangements?

6. Implement:
Implementation of the selected measures.
- Evaluate and monitor performance of the measure continuously
- Operation and Maintenance
- Upscaling and the it's spatial and temporal effects

Monitor, evaluate, adapt & learn: Every step needs to be evaluated and progress monitored.
- Learning at each step: what went well, what problems had to be overcome?
- Adjustment: monitoring during the process, adjust if required

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*Figure 8 Poster of Salinity Transition Approach for Progress*

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# A Background on 2 system approaches

## A.1 A Strategic Water Systems Planning Framework

Deltares (2022) has outlined a Strategic Water Systems Planning Framework, earlier known as The Framework of analysis for Integrated Water Resources Management Planning (IWRM; Loucks and Eelco, 2017). This framework is described in this section. The analysis framework for the management of water systems generally comprises five main phases, as shown in Figure 9. Phases I, II, and III focus on the development of a strategic plan, phase IV defines the actions needed for implementation and phase V is the actual implementation of the strategy. The first inception phase (Phase I) of the process identifies the subject of the analysis, the objectives and constraints. In the situational analysis phase (Phase II), the analytical tools for the analysis of the water resource system are selected or developed. Major activities in this phase typically include data collection and modeling. The models will be used to quantify present and future system performance. This performance can be based on multiple economic, environmental, and/or social criteria, to name a few. Scenarios will be developed that describe the future boundary conditions for the system. Identifying and screening alternative decisions can occur in this phase. If possible, no-regret measures will be identified for immediate implementation. In the strategy building phase (Phase III), alternative strategies will be developed and discussed with decision-makers and relevant stakeholders. This will include adaptive management elements to ensure that the preferred strategy is sufficiently robust and flexible in case the future develops differently than expected. This phase ends with the formulation of a mutually accepted integrated strategic plan for the development and management of the water system.

The Analysis Framework is generic in nature. It can be applied to strategic planning studies of different types of water systems including aquifers in coastal zones.

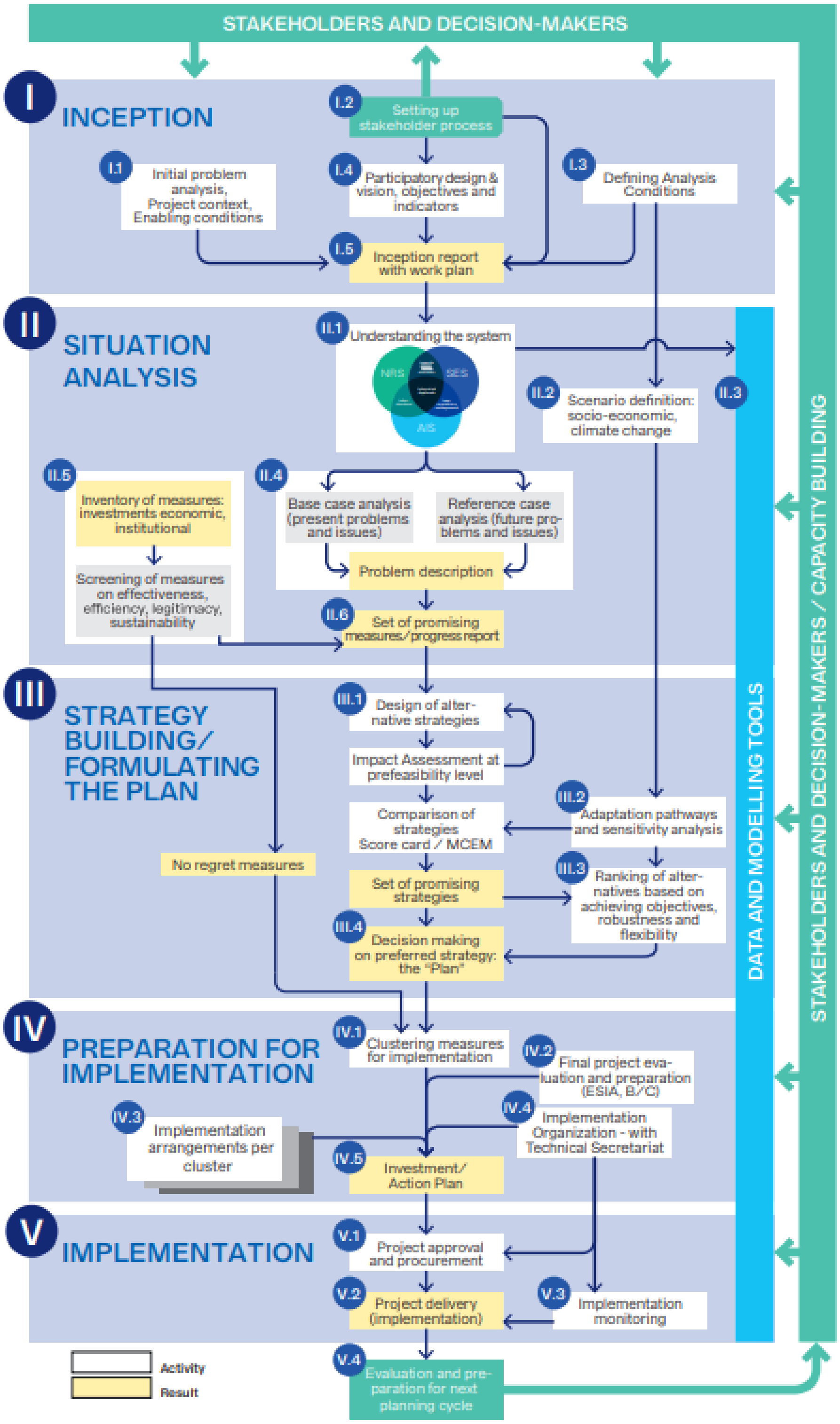


*Figure 9 Strategic Water Systems Planning Framework (Deltares, 2022)*

## A.2 Food Systems Approach

A food systems approach (FSA) is an interdisciplinary conceptual framework for research and policy aimed at sustainable solutions for the sufficient supply of healthy food (Van Berkum et al, 2018; FAO, 2018). An FSA analyses the relationships between the different parts of the food system and the outcomes of activities within the system in socio-economic and environmental/climate terms. Feedback loops are a distinguishing factor in systems thinking; they occur between parts of the food chain (production, processing, distribution and consumption) and from the socio-economic and environmental outcomes of food production and consumption (such as food security and soil depletion) back to that production and consumption. The FSA sheds light on non-linear processes in the food system, and on possible trade-offs between policy objectives. Systems thinking also broadens the perspective when seeking solutions for the root causes of problems such as poverty, malnutrition, and climate change.

The framework offers at least three benefits. First, it provides a checklist of topics that should at the very least be addressed when it comes to improving food security, certainly in relation to other policy objectives. Second, FSA helps to map the impact of environmental and climate changes on food security by pointing to the various vulnerabilities of the food system. In that sense the approach can contribute to the search for possibilities for strengthening the system's resilience to climate changes. Third, it helps to determine the most limiting factors for achieving food security, and hence identify effective interventions aimed at improving food security.

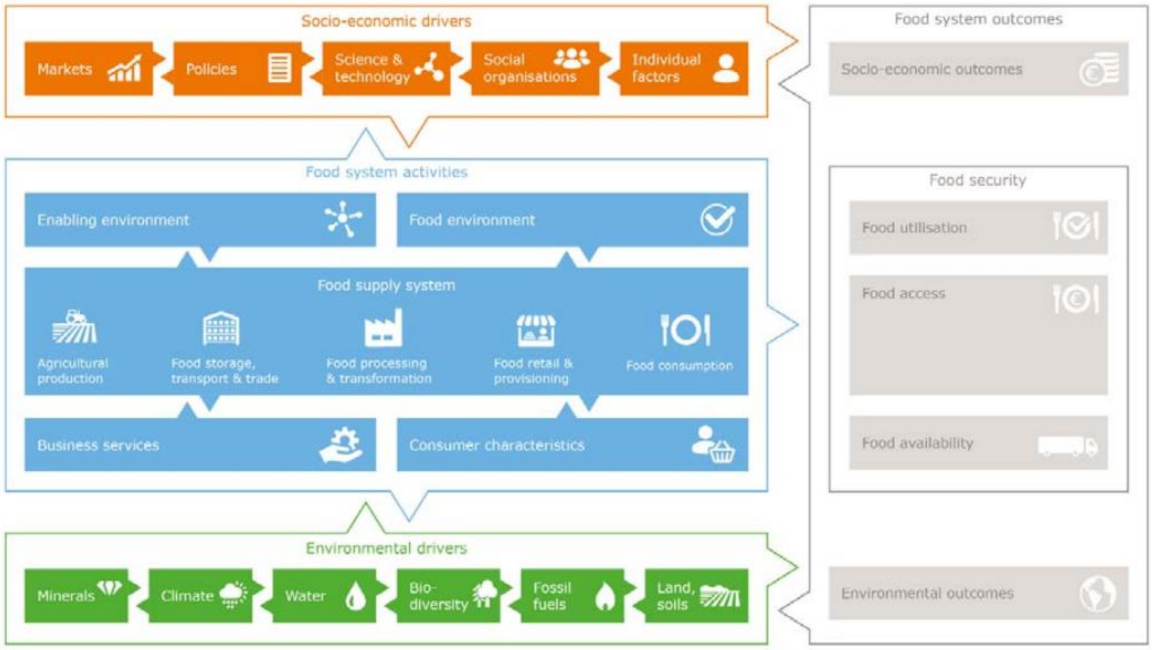


*Figure 10 The relationships of the food system to its drivers (van Berkum et al., 2018)*

Schematically, the food system can be described as in figure 7. The core of the food system are the food system activities, of food production, food storage, food processing, food retail and provisioning and food consumption (blue boxes in Figure 10). These food activities are influenced by socio-economic drivers like market, science and technology (the orange boxes) and environmental drivers like climate, water, soil, etc. (the green boxes). Outcomes of the food systems can be described in terms of food security in the FAO definition of food utilization, access, and availability, and socio-economic and environmental outcomes. The goals of the food system are enough food, safe and nutritious food, income equality (reduced income inequality) and resilience (addressing climate change and environmental degradation) and sustainability. And preferably these goals should be balanced. As resources are limited, and demand for food increasing, transition is taking place. Throughout this document, we will use the term food system as described here, so including production, storage etc., as described above.

Salinity in agriculture plays an important role, as it may reduce the yield of the crop, and the cropping possibilities in affected areas (both related to agricultural production, most left side of the blue boxes). Soil and water resources (green boxes) as well as marketing opportunities and science and technology (orange boxes) both influence the agricultural production under saline conditions.
Transition processes in general have an initiation period, a quickly changing period, and a later period, when new things get settled (Figure 1). Pathways can be described, analyzing what will change and who is involved, and towards which sustainable new situation. To assist in engaging together with various stakeholders in a process of transition, a guideline has been prepared (Verhagen et al, 2022) (Figure 11). The steps to go through are 1. Analyzing; 2. Understanding; 3. Prioritizing; 4. Exploring; 5. Preparing; 6. Implementing together, while all the time reflection and joint learning are part of the process.


*Figure 11 Steps to engage in transition pathways in food systems (Verhagen et al, 2022)*

# B Minutes of workshop

## B.1 National scale

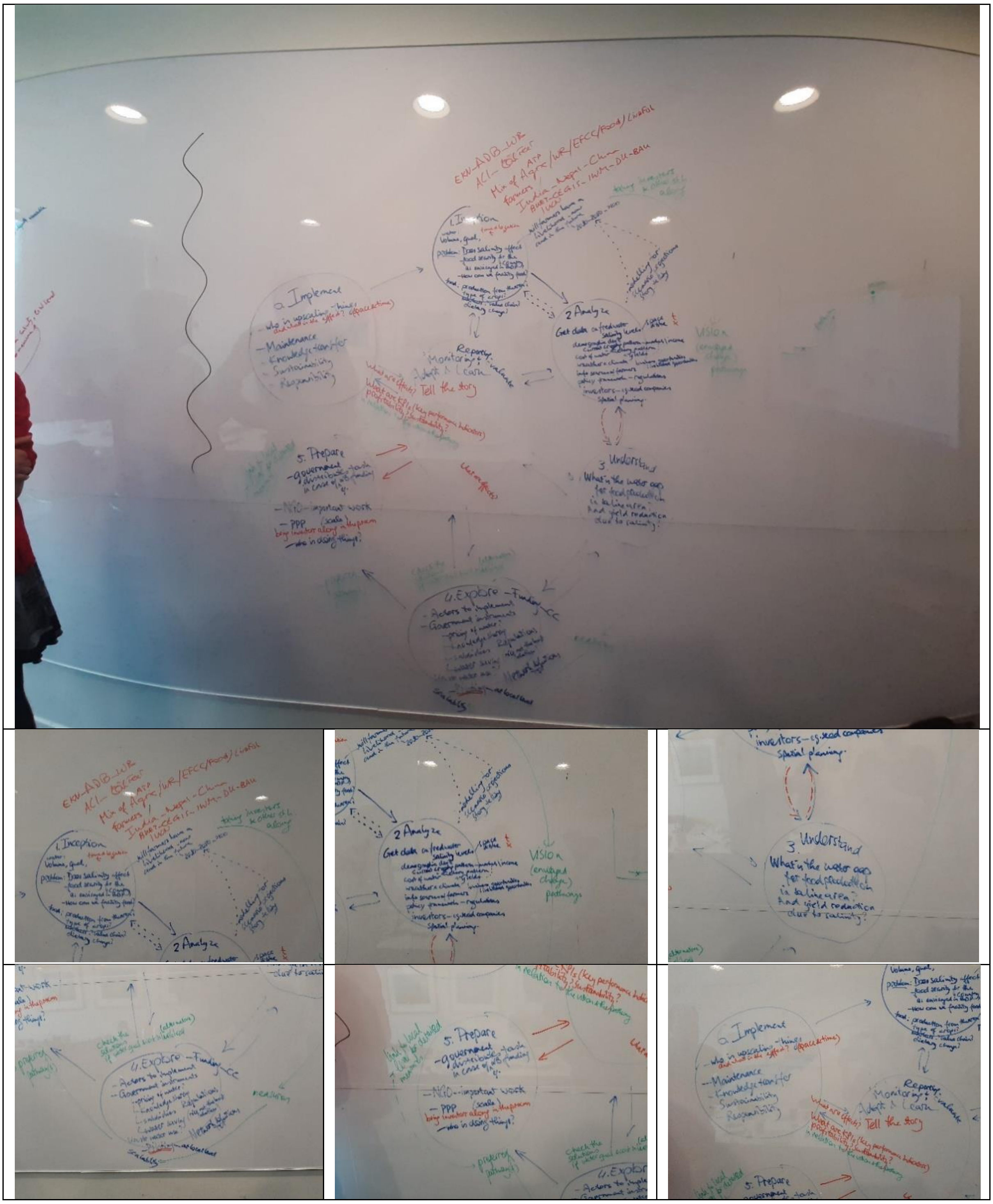


*Figure 12 Outcomes of workshop: National perspective*

## 1) Inception

Take home message: take investors & other stakeholders along

Main question: Will farmers have a livelihood now and in the future (2030-2050-2100)?

Type of questions:

- Water:
  - What is the volume and quality of available water (surface or groundwater)?
  - How does available fresh water change in time and space?

- Food:
  - Does salinity affect food security for the country as envisaged in BDP?
  - What type of food is produced in the area?
  - What are possible markets?
  - What is the value chain of current market?
  - Is dietary change foreseen in the future?

Different stakeholders:

| Ministries | Funders / Investors | Knowledge institutes | Neighboring countries | other |
|---|---|---|---|---|
| Agriculture | Embassy Koninklijke Nederlanden (EKN) | Bangladesh University of Engineering and Technology (BUET) | India | International Union for Conservation of Nature (IUCN) |
| Water Resources | World Bank (WB) | Dhaka University (DU) | Nepal | Farmers |
| Ecology Forestry Climate Change | Asian Development Bank (ADB) | Bangladesh Agricultural University (BAU) | China | |
| Food | Australian China Investment (ACI) | Center for Environmental and Geographic Information Services (CEGIS) | | |
| Livestock & Fisheries | Seed companies | Institute of Water Modelling (IWM) | | |

## 2) Analyze

Take home message: Vision pathways & incorporate envisaged changes

You should use different types of data and modelling techniques to envision possible future pathways that incorporates uncertainties and envisaged changes in the future

Type of data:

- Get data om freshwater and salinity levels in space and time
- Demographic information
- Current crop patterns / yields & markets / incomes / dietary patterns
- What are livelihood opportunities
- Cost of water
- Weather & climate
- Info of farmers
- Policy frameworks -regulations

- Investors – seed companies
- Spatial planning

Type of modelling
- Expectations on future salinity levels in groundwater

**3) Understanding**

Take home message: you should try to understand where critical tipping points / decision points are within the envisions pathways.

You should understand where there are conflicts between water availability and demand for food production.

Type of questions:
- What is the water gap for food production in saline area?
- What is the yield reduction due to salinity?

**4) Explore**

Take home message: check effectiveness of measures (goal / costs / livelihood) & form a set of preferred pathways that could first be testing on smaller scale (pilot).

Possible governmental instruments
- Pricing of water
- Knowledge sharing possibilities
  - Water saving
  - Crop vs water demand
- Subsidies
- Regulations
- Waste water use

You should explore if measures work on small scale by testing them in a pilot. A pilot phase should be made possible by the government. During this phase the scalability of measures should be investigated. The successfulness of a measure on pilot level can be different when it is upscaled to regional level, depending on side effects of measure, cost, practicability and others.

**5) Prepare**

Take home message: in order to make this step successful it is important to bring investors along in the process.
- government distributes tasks in case of WB funding
- NGO (important work)
- PPP (smaller scale)
- Who is doing things?

**6) Implement**

Take home message: in order to make this step successful it is important to bring investors along in the process.
- Who is upscaling things and what are the effects in space and time?
- Maintenance
- Knowledge transfer
- Sustainability
- Responsibility

**7) Monitor & Evaluate & Adopt & Learn & Report**

Take home message: the story should be told to bring people along and gain their trust

## B.2 Regional scale

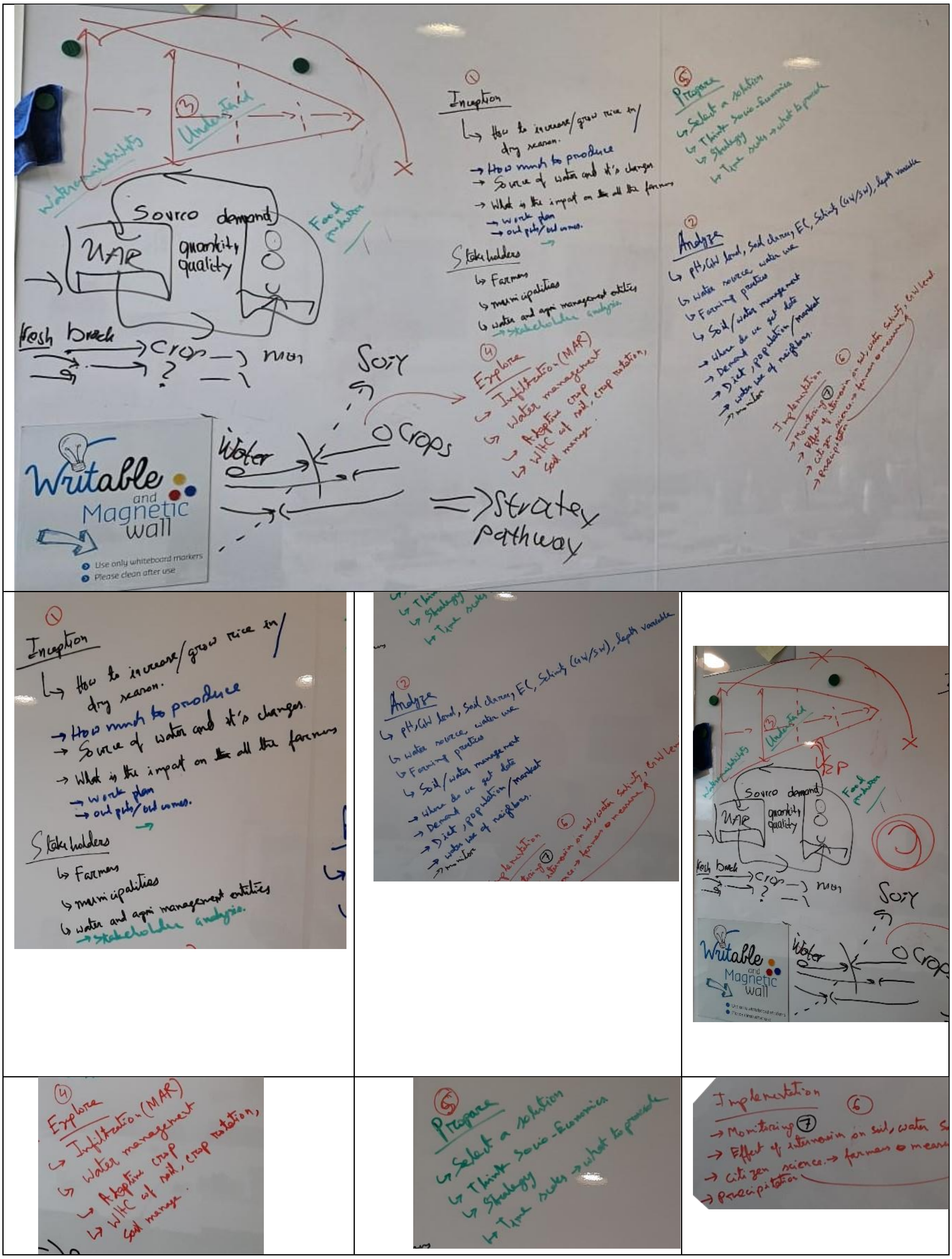


*Figure 13 Outcome of the workshop at local scale*

**1) Inception**

Take home message: focus on specific questions, conduct stakeholder analysis and prepare a plan with specific outputs and outcomes

Main question**:** How to increase food production, especially rice production during dry season in challenging saline environment now and in the future?

Sub-questions:

- Water:
  - What is the source of water and how will it change in the future?
  - How does available freshwater change in time and space?
  - Who takes the measurements of EC or ground water level and where to store it and how to access the required data?

- Food:
  - How much rice should be produced?
  - What is the impact of salinity on the farmer?
  - Why do the farmers want to produce rice?
  - Why can't rice be produced anymore?

Different stakeholders:

- Farmers
- Municipalities
- Water and agricultural management entities
- Non-government organizations

**2) Analyze**

Take home message: Data measurement scheme need to be setup in this step, data need to be collected and analyzed

Type of data to be collected:

- Spatially and temporally variable data on salinity in ground water, surface water and soil
- Ph
- Ground water level
- Source of water
- Farming practices
- Soil and water management
- Food demand, market and supply
- Population and diet
- Water use in the farms

Question to be considered: Where to get the data

**3) Understanding**

Take home message: Understanding of the interaction between food and water demand, and source of water is required and while looking at the future, uncertainty needs to be taken into account.

Type of questions:

- At what salinity level should a decision be made on cropping practices?
- How and when to decide on prioritizing adaptation of the water or crops or soil? Should the focus be on increasing water availability or saline tolerant crops or soil management?

4) **Explore**

Take home message: One or combination of measures needs to be considered which are feasible at the field level.

Possible adaptation measures:

- Increase infiltration and use of managed aquifer recharge (MAR) of fresh water at field scale
- Introduction of adaptive crop varieties and cropping practices
- Crop rotation
- Increasing water holding capacity of the soil and adaptive soil management

5) **Prepare**

Take home message: Select one solution, consider socioeconomics and time scales when preparing a plan.

Highlights of the discussion:

- Select and focus on one solution other multiple ones
- While preparing the plan, think about the time scale, consider what is achievable within the time frame
- Take socio-economic condition and local culture into consideration
- Decide on suitable strategies
- To understand who will fund the measures and who will be responsible for implementation, stakeholders analysis will be required which should be done in the “inception” step

6) **Implement**

Take home message: To understand how the implemented measures are performing, continuous measurements are required

Highlights of the discussion:

- To understand how the implemented measures are performing, continuous measurements are required
- Data on crop yield, salinity of ground water, surface water and soil, ground water level need to be collected and analyzed
- Citizen science can potentially be applied with farmers being involved in measuring and storing data

7) **Monitor & Evaluate & Adopt & Learn**

Here, depending on the impact of the implemented measures based on collected data, adjustments should be considered if required. After careful evaluation of the measures adopted, their effectiveness (or not) will be assessed and bottlenecks will be identified to keep improving the local situation using the interventions initially chosen, or new and different ones if they seem more appropriate after learning.