Ministry of Foreign Affairs

Saline Farming Assessment Mission Morocco

Commissioned by the Netherlands Enterprise Agency

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The Salt Doctors B.V.
Vloedlijn 47
1791 HK Den Burg
The Netherlands

Saline Farming Assessment Mission Morocco




Arjen de Vos (The Salt Doctors)
Victor Langenberg (Acacia Water)

September, 2022

Telephone +31 624 749 714
E-mail info@thesaltdoctors.com
Website www.thesaltdoctors.com
Chamber of Commerce 75774682

CONTENT

The pictures on the front page give an impression of some of the locations that were visited during the mission in Morocco. The top three pictures are taken around Errachidia (top left) and around Ben Guerir. The bottom picture was taken in a date palm plantation around Erfoud, with clear salt accumulation in the irrigated area around the trees.

Summary

Last May, The Salt Doctors and Acacia Water, were invited to undertake a water-agri reconnaissance mission in Morocco. This visit was organized by the Dutch Embassy in Morocco and supported by the Netherlands Enterprise Agency (RVO).

Together with local experts and stakeholders, we assessed the socioecological and hydrogeological conditions, discussed the current water-agriculture science and policy developments and also assessed the opportunities for integrated water management solutions at several research locations, as well as small and large farms in the areas around Errachidia, Ben Guerir and Agadir. Also, on-location salinity measurements were carried out and soil and water samples were collected for later processing.

The agricultural production and water management in all visited areas face increasing number of challenges with regard to lowering water quality (mainly salinity) and mis-use of the remaining ground and surface water. Of the eight sampled locations, seven locations showed (highly) saline conditions of both water and soil.

Based on the new insights in the current available infrastructure, the observed and expected salinity levels and the water demand vs. availability, specific locations have now been identified suitable for setting up exemplary demonstration trials regarding saline agriculture.

The stakeholders in Morocco are keen to collaborate with the Netherlands in these demonstrations, to jointly research and validate the performance of salt tolerant crops, climate-smart farming practices and integrated water resource management combined, also as a billboard for futureproof "water-agriculture".

A first action plan for the demonstrations is developed and presented at the end of this report, all linked to the needs and opportunities for further upscaling in Morocco.

Background

This report, financed by the Government of the Netherlands through the Netherlands Enterprise Agency (RVO), provides the results of a mission in Morocco to assess the possibilities for saline agriculture. The focus of the mission was to identify salt affected farms that are suitable for future demonstration activities and identify local partners who are willing to be part of future activities to help Moroccan farmers to become more resilient to increasing salinity levels under (fresh)water scarce conditions. A team of Dutch experts from the Dutch companies The Salt Doctors and Acacia Water have visited Morocco in May 2022 to work on the objectives, together with Mr. Niek Schelling (Agricultural counselor for Morocco and Senegal) and Mr. Mohamed Amine Moustanjidi (senior agricultural policy adviser) of the Dutch Embassy.

Objectives

The project has three objectives that were defined before the visit took place:

1. Suitable locations and salinity affected farms will be identified to execute pilots for saline farming research and development of appropriate farming measures.
2. Local partners will be identified in a participative team for preparation and execution of the salinity pilots, including local farmers, IAV, INRA, DRA, UM6P, FAO and Dutch partners, all with their specific roles.
3. The team will perform on-location salinity assessments and focus on various aspects related to water and technical infrastructure, as well as a first needs assessment from institutes and farmers.

To reach the objectives, several locations (Errachidia, Erfoud, Ben Guerir and Agadir) were visited and meetings took place with various stakeholders. At the visited locations, samples of soil and water were collected and analyzed, and these results are also provided in this report. Also, several literature sources were used to determine hydrogeology and environmental aspects of the visited locations.

Classification of salinity

In order to place the results of the analyzed samples into perspective, a general classification of soil and water salinity is provided first.

Classifying salinity of soil

Salinization refers to the accumulation of salts in soil or water, that can occur naturally or man-made (often caused by poor land and water management). The salt accumulation can cause negative effects on crop growth, soil structure and soil fertility. The effects depend on the actual salinity level (that can range from low, moderate to high in its simplest form), the salt tolerance level of a specific crop, the soil type (especially clay soils can be problematic), climatic conditions and the used farming practices. Salt-affected soils are often referred to as soils with elevated salt concentrations that interfere with normal plant growth and can include saline, sodic and saline-sodic soils (and many sub-categories depending on the type of salts). Table 1 provides a general overview of the different types of salt affected soils and the effect on the soil physical condition.

Saline soils contain excessive amounts of soluble salts that can reduce the ability of plants to take up water and can cause specific ion effects that negatively impact plant growth. So, saline soils can contain different salts and, in most cases, the major cations sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) are responsible for the elevated salinity levels. The salinity level is generally expressed as the electrical conductivity (EC, in dS/m), measured in the water phase of a specific soil to water ratio. Often, a 1:2 or 1:5 ratio (soil:water) is used, although the more common international standard is to measure the EC in the extract of a soil saturated paste (EC_e). Table 2 provides a general overview of the various salinity levels and the potential use of crops.

Sodic soils contain high amounts of adsorbed sodium ions which causes the degradation of the soil structure. Sodic soils are usually classified, based on either the sodium adsorption ratio (SAR) or the exchangeable sodium percentage (ESP) and/or the pH of the soil (pH>8.3). For SAR, the calculation is SAR= exchangeable $((Na/(Ca+Mg)^{-0.5})$, in meq/L. In both cases it's about the dominance of sodium (Na) which can cause soil structure to become unstable, which results in compact soils (in the case of soil high in clay content) with poor infiltration of water and air into the soil. The exchangeable fractions of these cations are measured in the extract of the saturated paste or in the solution of a 1:5 analysis. In general, a soil with SAR>13 is considered to be sodic.

Table 1. General classification of salt-affected soils, based on SAR, EC_e and pH values, and their effect on the soil physical conditions*

Classification	SAR	EC_e (in dS/m)	Soil pH	Soil physical condition
Sodic	> 13	< 4.0	> 8.3	poor
Saline-sodic	> 13	> 4.0	< 8.3	varies
Saline	< 13	> 4.0	< 8.3	normal
High pH	< 13	< 4.0	> 7.8	varies

* this is a general overview, eventual soil structure depends on many other factors, including management practices, mineralogy, and organic matter, among others

Table 2. Soil salinity levels and the potential use of various crops

EC_e (dS/m)	Salinity intensity	Potential use of crops
< 4	Slight	Yield of most crops only slightly affected, except for highly sensitive crops
4 - 8	Moderate	Moderate salt tolerant crops are suitable for cultivation
8 - 12	Strong	Salt tolerant varieties of conventional crops still suitable for cultivation
12 -16	Very strong	Limited number of highly tolerant varieties of conventional crops
> 16	Extreme	Only halophytes will produce satisfactory yields

Field visits

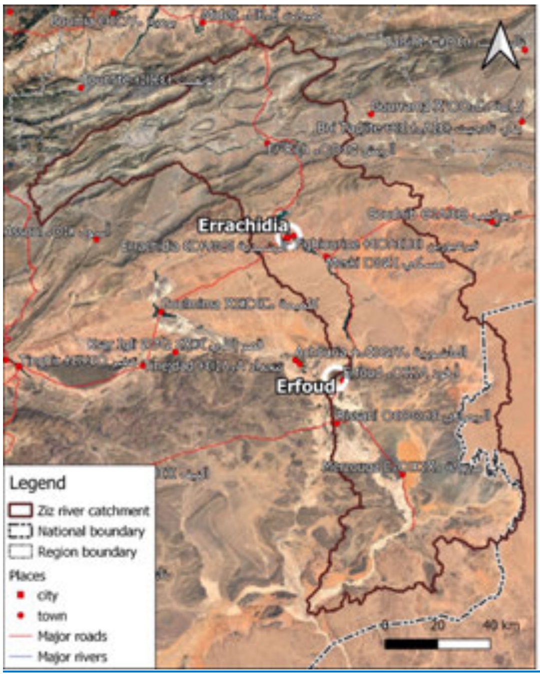
During the visit to Morocco, several locations and organizations were visited. On the first day, the province of Errachidia along the river (Wadi) Ziz was visited. This area include the Hassan Addakhil Dam and basin upstream and is the start of a vast oasis system. On the second day another River Ziz city Erfoud was visited. This is where the the Rivers Ziz and Rhéris join into the Daoura wadi and the oasis system more or less ends and in this area water scarcity and salinity are a big concern for farmers. On the third day the office of INRA in Rabat was visited, after which we traveled to Ben Guerir, close to Marrakech. On the last day the area just south of Agadir was visited. These locations are indicated in figure 1 followed first by a Quick Scan to the explanatory geohydrology, status and trends in water availability and quality in relation climate change and then a detailed description of the meetings and visited locations.

Figure 1. Impression of the areas that were visited, with the four white circles indicating the areas where field visits took place (Errachidia, Erfoud, Ben Guerir and close to Agadir).

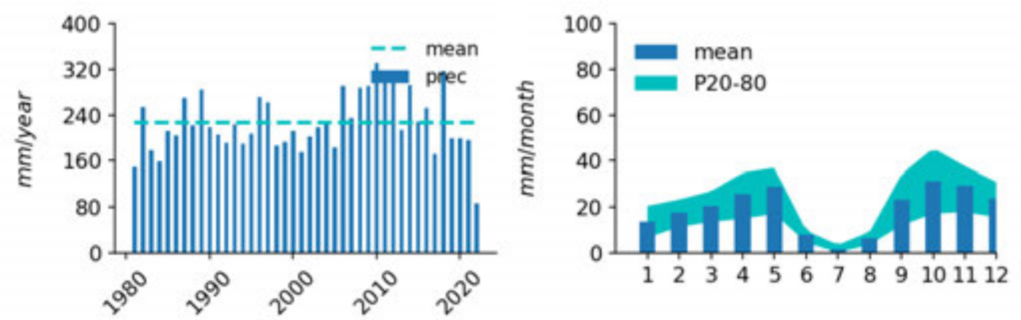
Monday 23 May
Location: Errachidia
Organisation: local INRA office (Laboratoire National de Culture des tissus du Palmier Dattier), second visit to ABH (Agence du Bassin Hydraulique du Guir-Ziz-Rheris), farm visit
Who: 6 staff INRA, 4 staff ABH, local farmer, Amine Moustanjidi (Dutch Embassy)

Scanning region and environment

Errachidia and Erfoud are both cities located along the Ziz river in the Ziz river basin. The Ziz river originates in the High Atlas, and flows southward past Errichidia and Erfoud where eventually it joins the Rheris and Maider river to form the Daoura river flowing into the Algerian desert. All of these rivers are ephemeral in nature, only supporting flow of water in short periods in the wet season and even potentially no water at all in dry years.
For the Ziz river itself,in order to control and regulate the surface water flow, ensuring irrigation supply and flood control, the Hassan Addakhil Dam was built in 1971 with a capacity of 380 Million cubic meter (Mm^3). Since the beginning of operation of the dam in 1971, the drainage of the natural ecosystem has changed completely. Based on inflows to the reservoir, water is released through canals only three to four times per year, typically during the summer. Each release occurs for a period of about 20 days. The annual outflow from the reservoir is about 105 Mm3, from which 85% is used for irrigation while roughly 15% is lost due to evaporation and leakage. In the MZV and Tafilalt plain, the overall potential of surface water is about 154 Mm^3, which includes the reservoir input with 84 Mm^3, the contribution of the intermediate basin (including springs) with 55 Mm^3, and an external source of 15 Mm^3 transferred via a small diversion dam from the neighboring basin to the west, the Rhéris basin. In other words, the Ziz river is highly controlled and use of its water is dictated by the dam and its board, almost all of which is already allocated for existing irrigation schemes.



Upper ziz:



Lower ziz:

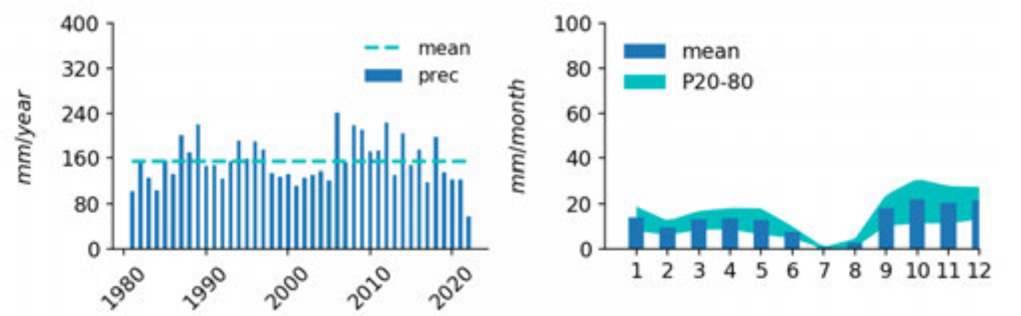


Figure 2. Overview of the area of Errachidia and Erfoud and some of the precipitation data. Precipitation changes somewhat from up to downstream areas in the basin.

Hydrogeology

The hydrogeology of the Ziz basin area is relatively complicated. Multiple interconnected aquifers exist in the area, some deeper, some shallow. The deep aquifers tend to support saline water however, and they are mostly little exploited. The more shallow aquifers in quaternary deposits are mostly used. They also have issues with salinity however, especially downstream.

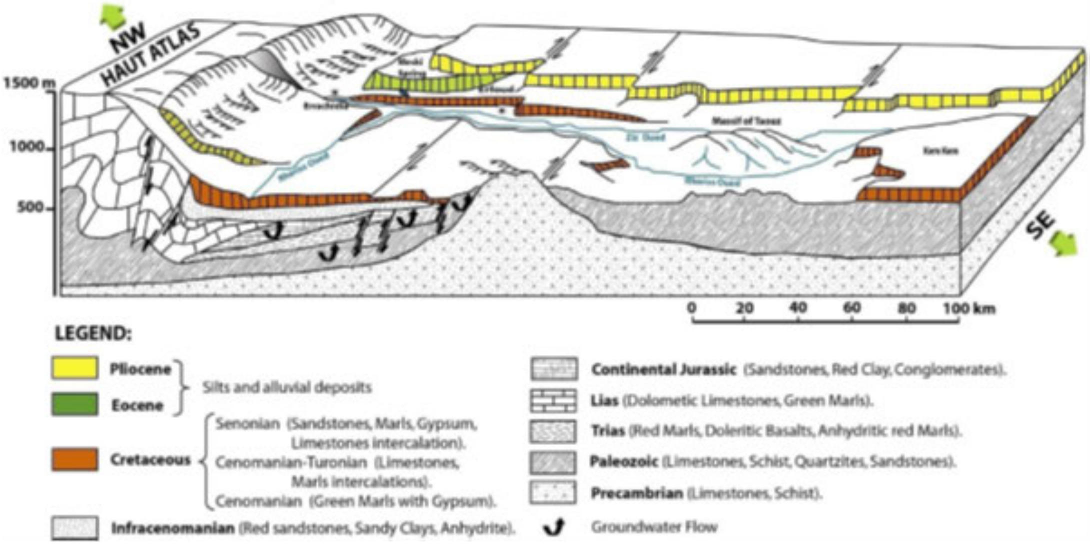


Figure 2. Groundwater in the Ziz river basin; water infiltrates in the High atlas, causing Artesian groundwater to occur in the lower basin area down to Erfoud

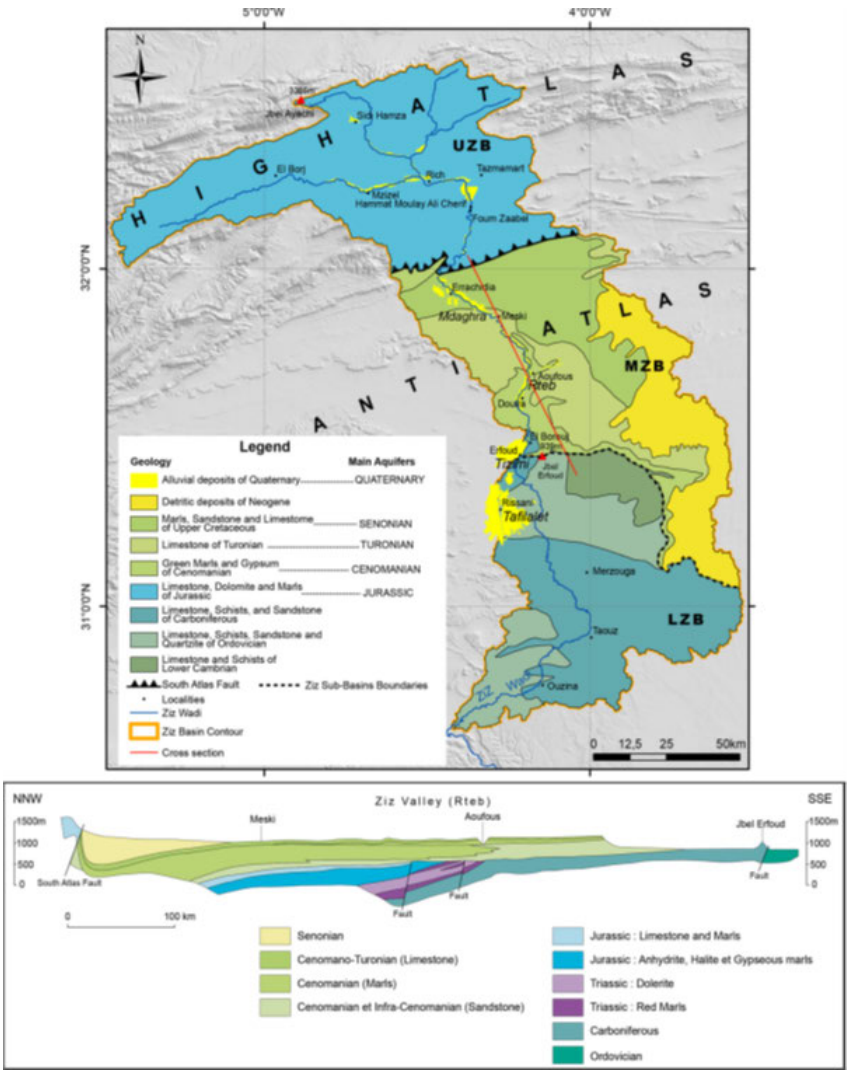


Figure 3. Geology of the Ziz river basin area; geological map (above) and geological cross-section (below)

As a consequence of the geohydrological structure of the river Ziz basins, for recharge the subsurface water resources depend on sporadic infiltration of flood water and agricultural or domestic return flows. Especially since the building of the Hassan Addakhil Dam, this is likely quite low while return flows from agriculture and households are likely to have quality issues (nitrate and/or salinity). The climate change effect makes the management of the Hassan Addakhil dam a sensitive issue. According to Ezzine (2017) the inflow to the Hassan Addakhil dam will decrease by 30% in 2050. As such, this aquifer is highly vulnerable to overexploitation and contamination.

The meetings and field visits

The day started with a visit to the regional office of INRA (Laboratoire National de Culture des tissus du Palmier Dattier). The work that is performed by INRA focusses on the oasis systems, where date palm is the most important crop and many farmers also use intercropping with fodder (mostly alfalfa). In short, there are two systems within the oasis system; the traditional system and modern farms. The modern farms often have their own wells and also analyze the soil and water regularly. The traditional systems are less intensive and are dependent on the local authorities for results about salinity levels. Many of the springs and wells are located in the valleys of the mountainous areas. Generally, the more upstream these are located in the oasis (and closer to river Ziz and shallow groundwater) they can produce water of low to moderate salinity levels (2-4 g/L), on contrary downstream and further away from the Atlas source the farmers have to deal with high to severe salinity level (8-12 g/L). Groundwater is the source of the irrigation water and shallow groundwater differs in salinity compared to deeper groundwater (8 vs 12 g/L, respectively). Through springs deeper ground water may come up allowing chloride salts, and also in particular iron salts to precipitate at surface hampering crop growth. Besides the date palm, also research is taking place with trees like acacia, eucalyptus, wheat, tamarix and fruit trees were mentioned as well. The staff of INRA indicated that the cultivation of fodder is not very profitable for the farmers and there is great interest in the cultivation of cash crops (like vegetables), to be used in an intercropping system with the date palm. Also, there is increasing water scarcity in the oasis system, so solutions need to focus on water saving and reuse (technologies) or on the use of crops that require little water and can produce under erratic water quality and quantity in a warming region. Additionally, the potential solution should not only focus on short term solutions but also take the sustainability of the cultivation into account (>5-10 years). INRA performs research, but also works together with farmers. Most farmers are organized in co-operations. Many of the cultivation systems are now connected to deep-rooted cultural practices. So, besides taking salinity and water scarcity into account, the proposed solutions should also focus on the long-term sustainable use within the oasis system and take historical and cultural practices into account. INRA manages a lot of data on soil and water salinity which they are willing to disclose and share, although a large part comes from the 90's and there is a need for updating the monitoring. Also, INRA indicated that they have interest in a scientific approach regarding the monitoring of the water quality and quantity.

Image 1. Impression of the visit to the ABH office.

After INRA, a visit to ABH was organized. As ABH, they have the mandate to monitor the quantity and quality of the water, with a strong focus on drinking water. They have a lot of data on the different basins and are willing to share this data. However, the data is a bit scattered in time. For 2004 there is data and then from 2016 up until now. Based on this data, there seems to be little variation in salinity in time, but there are local areas with elevate salinity levels (that are linked to geohydrological conditions of those areas according to ABH). They work on projects related to desalination. The costs are around 10 dirham per cubic meter of water, so around 1 euro per m^3. This is cost effective for drinking water, but not for the use of irrigation (for instance, a crop that requires 500 mm of water during the crop season, needs 5000 m^3 of water per hectare, so this will cost 5000 euros). If a farmer wants to install a well, they need to get permission from ABH first. So, they are the organization that deals with the overall water use, but irrigation management is not part of their activities.


Image 2. Farm visit just outside Errachidia.

Later in the afternoon, a small-scale farmer was visited just outside Errachidia (see image 2). The farmer had recently invested considerable -with support of the government- in the farm setup. The farm was new and the activities started only one year ago. A well was installed that pumps water (solar powered) into an open reservoir. The reservoir itself was not covered by a floating cover or a shade net. From the reservoir, gravity irrigation takes place. The farmer cultivates different crops, some of which are irrigated by means of drip irrigation, others by sprinkler (cereal crop) or surface irrigation. Date palm is planted at the farm and some crops are cultivated close to the date palm where irrigation takes place. Also, plots with maize, cabbage, faba bean, and pepper were observed, with different densities of drip lines (for instance, maize was cultivated in a plot with a high density of drip lines (drip lines close to each other), whereas faba bean and pepper were irrigated by a single drip line, with a relative large space between the planting lines (large distance between drip lines). The farmer indicated that he has problem with achieving good yields and he is not sure how to deal with this. A white layer is visible at the soil surface in different parts of the farm (see image 3). Among others, at the plot where faba bean and pepper are cultivated, this white layer is visible around 20 cm from the drip line on both sides. Also, along the furrows that are used for surface irrigation this white layer is visible. In general, this white layer are salts, but it should be confirmed which salts are present. For instance, calcium carbonate, calcium sulphate or magnesium salts can easily precipitate and become visible as a white layer around drip lines on the soil surface. But sodiumchloride is a much more problematic salt that can affect crop performed, soil structure and soil fertility. In the field, the quality of the irrigation water was determined. The EC of the irrigation water was 1.8 dS/m, which can be classified as low salinity. In general, there should be little direct effects on most crops with these salinity levels. But if sodium concentrations are high, these low salinity levels can still cause problems related to the crop and soil, if salt accumulation takes place in time. For this, also the sodium (Na^+), calcium (Ca^{2+}) and potassium (K^+), as well as the nitrate (NO_3^-) of the irrigation water were recorded and the respective concentrations were 120, 310, 6 and 46 mg/L. So, based on these temporarily field results, it seems that mostly calcium is present in elevated concentrations, although the recorded sodium levels can cause problems if accumulation takes time. A first soil salinity assessment (based on the 1:2 method for which 1 volume part of dried, sieved soil is mixed with 2 volume parts of water, and the water phase is analysed for salinity) showed a salinity level of 1.3 dS/m (EC 1:2). Based on the soil type (which seems to be loamy sand or sandy loam) this value of 1.3 dS/m can be calibrated by multiplying the value by 3.5. This means that the standardized soil salinity level (based on the extract of a soil saturated paste (ECe) is in the range of 4.6 dS/m. This salinity levels can affect salt sensitive crops and if the soil is allowed to dry out (no irrigation or rainfall for a considerable amount of time) the salinity goes up and salts may precipitate in the soil affecting even more tolerant crops. Assuming that the soil is irrigated frequently, crops like faba bean and cabbage can often still produce high yields. Since this is not the case at the farm, it is likely that other factors besides salinity are affecting the crop performance (for example irrigation management, pests and diseases, fertilizer management, heat stress, among others). The recorded pH was 7.5, which is not a direct concern, although optimal pH levels are in the range of 6-7, in general.

At the farm, there was no use of raised beds, and no use of mulch or cover crops. The drip lines, that are exposed at the surface, showed high variation in line spacing, with no salt accumulation visible in high density drip line plots (like the maize) and visible salt accumulation in the parts with a low density of drip lines (like the faba bean/pepper plot).

Image 3. Visible salt accumulation near the drip lines and irrigation channels at the Errachidia farm.

Tuesday 24 May

Location: Erfoud (area Errachidia. Lower Ziz, start of Anti Atlas region))

Organisation: ANDZOA (l'Agence pour le Developpement des Zones Oasiennes et de l'Arganier), including field visit to two farms

Who: 6 staff members ANDZOA, 3 staff members INRA, local farmers, Amine Moustanjidi (Dutch Embassy)

This second day started with a meeting at ANDZOA in Erfoud. Around 32% of Morocco can be classified as "oasis area". ANDZOA was established by the Ministry of Agriculture and its mission is to protect and develop the oasis area as well as the argan (tree) area.

For this, ANDZOA initiates and performs technical, socio-economic and environmental studies for support to a range of innovative projects (perfume roses, argan, safrene, dates, clean energy or paper pulp from palm wastes) that need to secure sustainable development across socioeconomic, sociocultural and socioecological as defined by the ruling policies. The construction of needed infrastructure is part of their activities, as well as education and training, health, housing, and tourism, among others. Local development projects, aimed at improving the living conditions of the community are also part of the activities and also considered in Integrated Water Resource Management (IWRM) and business development and value chain perspective. Much of the research and implementation in agriculture are performed together with INRA. Erfoud itself is located close to the visible end of the catchment area of the oasis ecosystem (see image 4) after which it flows into the Daoura river system to disappear into the Sahara . Around the water catchments near Errachidia the salinity levels are low, but near the end of the oasis ecosystem around Erfoud, the salinity levels are reportedly around 4 to 6 grams per liter. At present, only some salinity mapping is performed together with INRA, but no other activities regarding salinity is taking place. It was mentioned that the farmers in this area are hesitant to start using new crops, unless there is a clear market opportunity. Some of the research in other areas in Morocco focus on fodder crops and quinoa under saline conditions, but the success for implementation is small due to limited market demand for these crops. The cultivation of cash crops like vegetables seems to be more interesting for the famers. Most farmers are aware of the worsening salinity challenges here but have little knowledge on how to mitigate or adapt to it.

Image 4. Impression of the catchment area of the oasis ecosystem with the main water catchment area around Errachidia (with low salinity) and Erfoud near the end of the oasis, with high salinity.

In the afternoon, two farms were visited around Erfoud. Both farms focus on date palm (the most important crop in the oasis), although the second farm also cultivated alfalfa in between the date palms. This intercropping provides the farmers with additional income, which is especially important during the first few years after planting the date palms, since it takes 3-4 years before the palm starts producing the dates. At the first farm (referred to as “oasis 1” later in the report) the salinity level of the irrigation water (source=groundwater) was 14.6 dS/m. At the second farm (“oasis 2”), that was located relatively close to the first farm, the groundwater salinity level was 8.8 dS/m for one well and another well at the farm showed a salinity level of 9.3 dS/m. So, at relatively small distance the salinity level of the groundwater can show a large variation. The farm “oasis 1” pumps up the groundwater to an open reservoir (see image 5, left) and subsequently uses drip irrigation to water the date palms. The farm “oasis 2” pumps up groundwater and uses a system of “gravity irrigation” to directly flood the fields were the date palms and the alfalfa grows. It was also mentioned that at “oasis 2” there is also use of drip irrigation and also beetroot is cultivated sometimes in the field. For the first farm, also the pH and the concentrations of calcium, sodium and potassium were recorded, and the results are listed in table 3. Based on the results in table 3 it can be concluded that the high salinity levels of the irrigation water are mainly caused by high sodium levels. It was mentioned that the yield of the date palm at “oasis 1” is only around 30% compared to the yield closer to Errachidia, where salinity levels are much lower.

Table 3. Some characteristics of the irrigation water at the farm “oasis 1” that was visited near Erfoud.

location	EC (in dS/m)	pH	Ca^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)
Oasis 1	14.6	7.1	670	2700	37

Image 5. At the farm “oasis 1” an open water reservoir isa used to store the groundwater before a drip irrigation system provides the water to the date palms (image left). At the farm “oasis 2” (image right) groundwater is pumped up and directly used to flood the fields where date palm and alfalfa is growing.

Image 6. Impression of the area where the farms “oasis 1” and ”oasis 2” are located (top image), with the middle picture showing “oasis 1” and the bottom picture showing “oasis 2”.

Wednesday 25 May
Location: Rabat
Organisation: INRA
Who: 4 senior staff of INRA office Rabat, Niek Schelling, Amine Moustanjidi (Dutch Embassy)

On Wednesday a meeting took place at the office of INRA in Rabat, to discuss the progress so far, the ambitions of the project and to explore opportunities for future collaboration. INRA is actively involved in the implementation of the Generation Green 2020-2030 program, the ten-year plan for the further growth and sustainable development of the agricultural sector in Morocco. INRA sees good opportunities to include Dutch knowledge about water management and saline agriculture within this program. There seems to be opportunities to use some of the existing budget of INRA to work more on water management and saline agriculture, starting with a demonstration project. This budget however, can only be used for the expenses of INRA, so for the costs of the Dutch partners additional funding has to be identified.

Thursday 26 May
Location: Ben Guerir
Organisation: UM6P (Mohammed VI Polytechnic University)
Who: 5 staff members UM6P, 4 staff members INRA (offices Rabat, Marrakech, Agadir), Director and staff of DPA (Direction Provinciale de l'Agriculture), Niek Schelling, Amine Moustanjidi (Dutch Embassy)

The main purpose is to look for adaptive strategies, solutions and alternative crops to mitigate salinity effect in Sed Masjoun plane.

Scanning region and environment
The area of focus and visit ca. 30 km north of Marrakech is located in a place known to hydrologists as the Bahira plain. The Bahira plain hosts the dry lake of 15Sedd el Mejnoun (since mid 80's largely dried up) and the Bahira aquifer in the sedimentary deposits below. No significant water bodies or rivers are present in the area, only small seasonal streams. The area is characterized by a continental semi-arid climate with Saharan influences; the average annual precipitation is around 200 mm/year (see below), while the temperature varies between ca. -4 °C in winter and 50 °C in summer as min/max values. The average annual evaporation is 2,619 mm. Agriculture and livestock are the main economic activities. Groundwater is the only resource available for irrigation and drinking water.

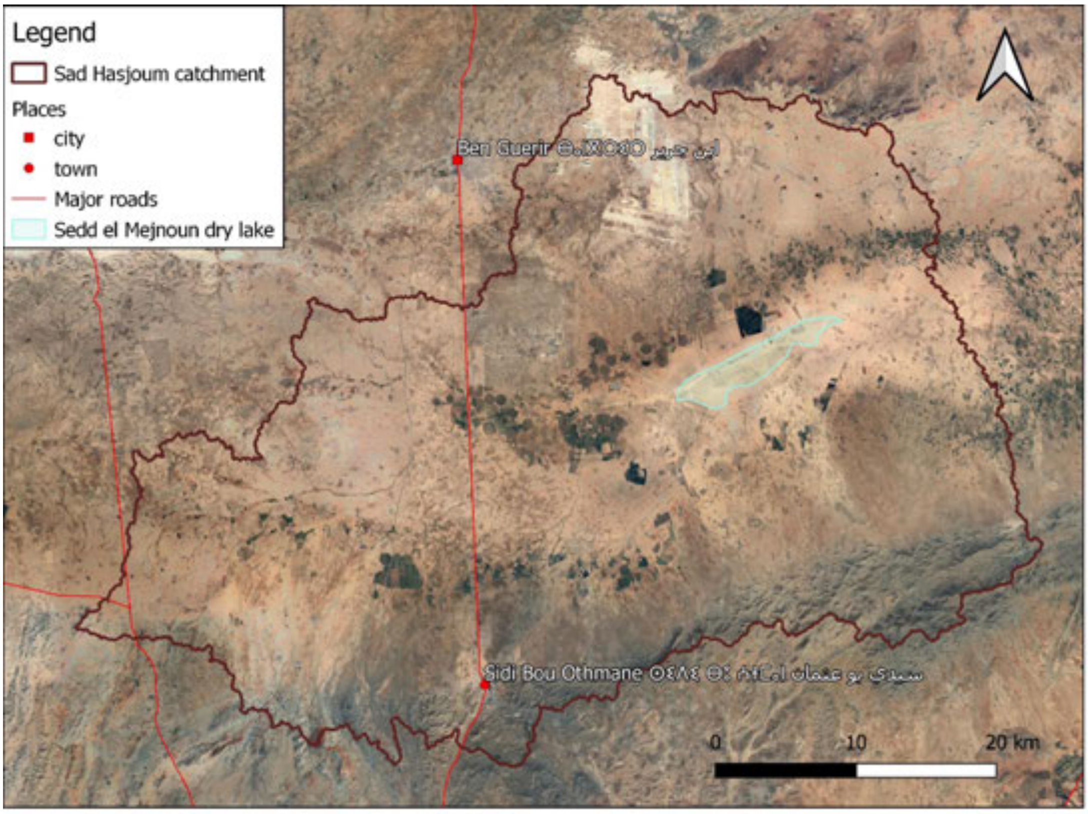


Figure 4. The Sedd el Mejnoun area

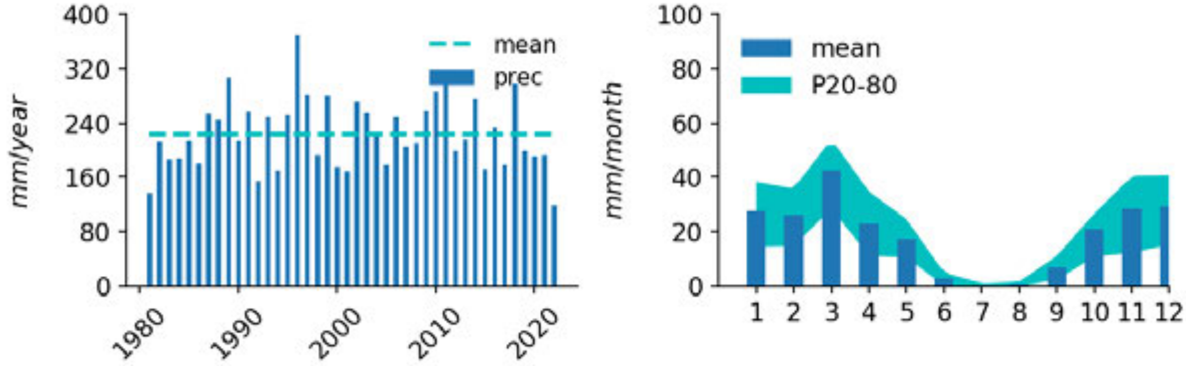


Figure 5. Impression of the Sad Masjoun area and the rainfall at Sedd el Mejnoun area of around 230 mm/ yr.

Hydrogeology

The groundwater converges towards the sebkhas of Sed El Mesjoune and Zima, where the piezometric levels become very close to the ground. They constitute low areas in relation to the surrounding reliefs of the Jbilets located to the South, Mouissat to the West, and Gantour to the North. Water in the Bahira aquifer mainly seem a remnant of previous ages, very little active recharge seems to take place. Deeper groundwater may be connected with systems in the High Atlas with higher recharge rates, but research is lacking.

The sustainable use of water and soil resources in this region is extremely challenging. The depth of the water table is largely variable; it oscillates between 20 and 70 m with a majority of the wells deeper than 40m. This highlights the overexploitation of these waters in irrigation causing a continuous depletion of the water table as recorded by Zouahri *et al*., 2017.

The highest ECs are ca. 15 dS/m, averages around 4 dS/m increasing towards Sed El Mesjoune peripheries. Therefore, high salinity is prevalent in the current groundwater sources, and the remaining pockets of fresh groundwater likely receive little recharge and are therefore vulnerable to overexploitation. Consequently, this water is not very suitable for irrigation; it can damage the soil and affect the other groundwater tables.

Presentation of Rehamna province

The text below is a summary of the initial meeting in the office of UM6P, composed by UM6P:

Rehamna province was created in 2010. It is characterized by an arid/Semi-arid climate. The strategy of Green Morocco Plan in this region focused on promoting the development of diverse sectors:

- Cactus sector: through the plantation of more than 30000 ha of cactus plants. However, the cochineal has devastated the whole cactus of the region. To overcome this problem, eight resistant cactus varieties were developed and planted in 500 ha in 2020, with an objective of another 1500 ha in 2023.
- Cumin sector: with a protected geographical indication (IGP), there were establishment of a cumin valorization unit.
- Development of Sardi race through genetic amelioration with 1200 breeders in the province.
- Quinoa value chain
- Beekeeping
- Conversion of the irrigation system of an area of 800 ha.
- Pomegranate trees with 10000 ha.
- 15 valorization units

With the start of Green Generation Program, other alternative crop is promoted such as argan tree, carob tree, quinoa, and cumin. Other pastoralist crops are also promoted such as Atriplex, which has high tolerance to salinity. For instance, 1000 ha was planted for fodder shrubs in this saline region.

Presentation of Bahira plane with the Sedd el Mejnoun lake

With an area of 30 000 ha, Sed Masjoun soils are characterized by variable salinity levels. In areas of low salinity levels, farmers grow olive trees and vegetables, whereas Atriplex dominates the area of high salinity levels. Other native crops as *Piganum armala* is found in this area besides pistachio trees, Aloe vera, saffron, Gogi and goat milk, aromatic and medicinal plants.

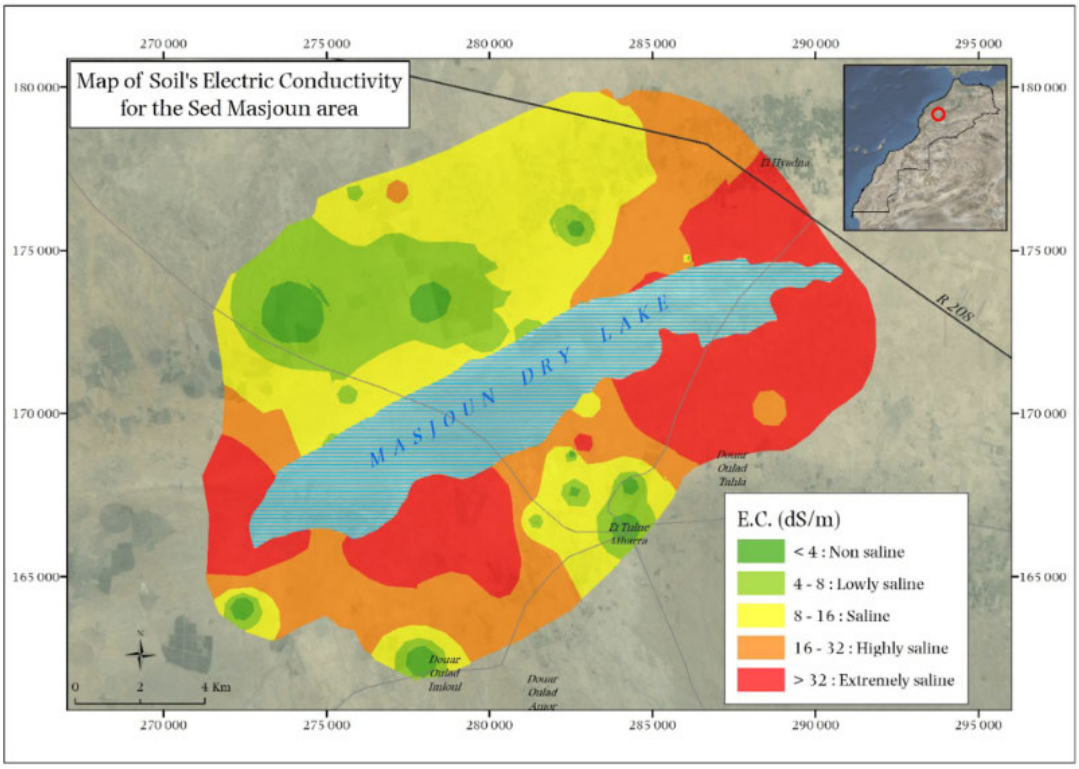


Figure 6. Soil Salinity map of Sed Masjoun

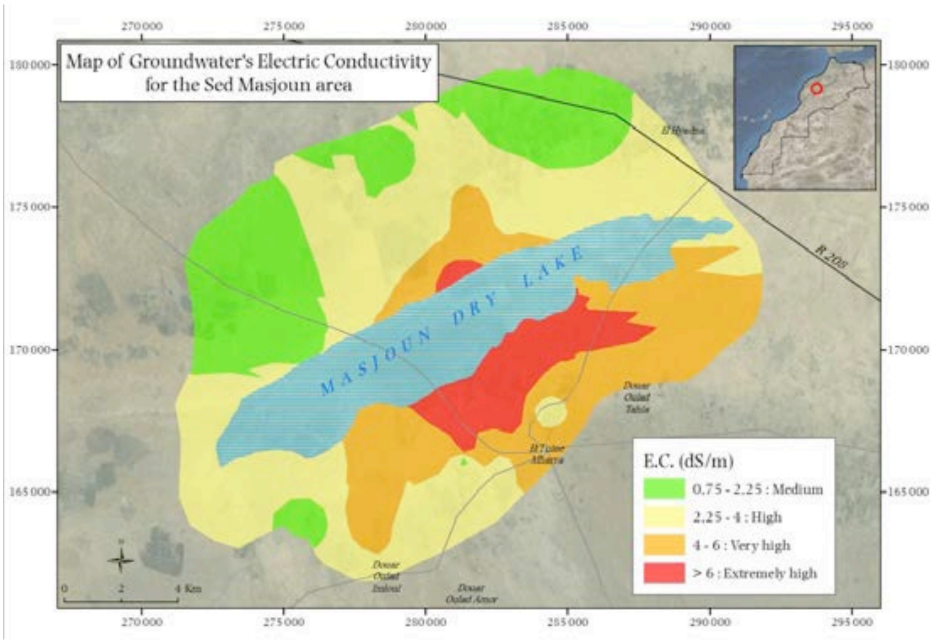


Figure 7. Groundwater's salinity of Sed Masjoun area

Strategies of adaptation to salinity in Sad Masjoun

- Introduction of alternative crops resistant to salinity such as quinoa and Blue Panicum.
- Increasing rangeland areas
- Developing platforms for crops resistant to drought and salinity
- Developing platforms of agroforestry
- Using nano-irrigation technic
- Developing camel and milk goat chain in this area.

After the meeting, a tour of the experimental fields and the labs at UM6P was organized. There are several fields that are being used to test different varieties of cactus and quinoa and a nursery is present where Gogi is cultivated, among others. The experimental fields at UM6P are not salt-affected.

Image 7. Part of the nursery at UM6P, with the Gogi trees visible.

Image 8. Impression of the experimental fields at UM6P, with the cactus trial visible on the left and the quinoa trial visible on the right.

After visiting the experimental fields of UM6P a field visit took place to several farms in the Sed Masjoun area. It is the ambition of UM6P to start up an experimental farm in this area, with a special focus on saline agriculture. The first farm that was visited, that is also regarded as a potential location for this new experimental farm, actually stopped pumping up groundwater and stopped farming due to high salinity. The well was constructed by the Moroccan government, but most likely the well is too shallow and high salinity water was pumped up (up to 47 dS/m, this is more or less seawater salinity). At present the open reservoir, that was used to store the pumped-up water before irrigation, is empty (see image 9). Also, the soil here contains many rocks that will prevent optimal soil preparation and crops like potato and carrot cannot be cultivated in soils so rich in rocks. There are machines available to remove these rocks and the Moroccan government provides subsidies for this. It was also mentioned that the deeper groundwater (>230 meters) is low in salinity. With an additional well this location can have both salt water and low salinity water. With an additional mixing station, it is possible to use several salinity levels to test various crops and cropping systems. So, with a considerable investment, it is possible to construct an experimental farm here. However, this will take a considerable amount of time as well, making this location not ideal for a quick pilot.

Image 9. Impression of the first visited farm in the Bahira plane. Here, highly saline water was pumped up and the farmer had to stop farming due to this high salinity. Also, the soil contains many rocks that have to be removed before optimal use of the soil is possible.

Other farms in the same area cultivate mainly olives but intercropping with alfalfa and some vegetables is also taking place. Many farmers use a Spanish variety of olive that provides fruits after two years, in comparison with the Moroccan variety that takes three years before fruiting starts. So, a new farm has to invest time and money for at least two years before the first revenues come. In this regard, intercropping with cash crops can be very interesting for farmers, in order to provide revenue within the first year. All the successful farms seem to have deep wells (>230-240 m), to ensure low salinity water for irrigation. Water samples from 2 farms were analyzed in the field and the results are given in table 4. Based on the results of table 4 it seems that a relatively small difference in the depth of the well can have a great effect on the salinity level (although the farms were located a few kilometers away from each other). However, it was also mentioned that "farm 2" did not use a casing around the drilled well, so it is also possible that saline water from other (shallower) layers is entering the well and is causing the high salinity levels. The elevated salinity levels seem to be linked to elevated sodium levels. The "farm 2" has stopped pumping up groundwater due to increasing salinity in the open water reservoir. The farmer will first clean the reservoir (remove salts) and then continue to pump up the groundwater. But based on table 4 the salinity level of the water he is using is very high and only a few crops can cope with these salinity levels. The field he irrigated was cultivated with alfalfa and a soil sample has been collected here. An additional soil sample was collected from an adjacent field that was not irrigated, as a comparison. It was also mentioned that the farmer has planted trees in the past, but these trees have died (most likely due to high salinity). A short visit to the actual dry lake (see figure 2 and 3) also took place and a soil sample was collected here as well.

Table 4. Some characteristics of the irrigation water of two farms in the Sad Mesjoun area.

location	Depth well (m)	EC (in dS/m)	pH	Ca^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)
Farm 1	240	2.8	7.2	150	440	4
Farm 2	210	12.5	7.5	300	2400	14


Image 10. Impression of the farm that has irrigated a field of alfalfa, although irrigation water salinity levels were recorded at 12.5 dS/m. At this farm, two soil samples were collected (later referred to as "UM6P-irrigated" vs "UM6P non-irrigated").

Image 11. Field visit to the dry lake

Friday 27 May visit INRA Agadir, Domaine Experimental Melk Zhar Belfaa
Location: Agadir
Organisation: INRA
Who: Jamal Hallam, senior researcher INRA

Scanning region and environment
Agadir location in Souss Massa catchment is located along Souss river in the Souss valley. Souss river originates in the High Atlas to the north and Anti-Atlas to the south, flowing westward towards the Atlantic Ocean passing the cities of Taroundant and Agadir. Souss river has an average flow of 4 m^3/s at the Agadir INRA location.

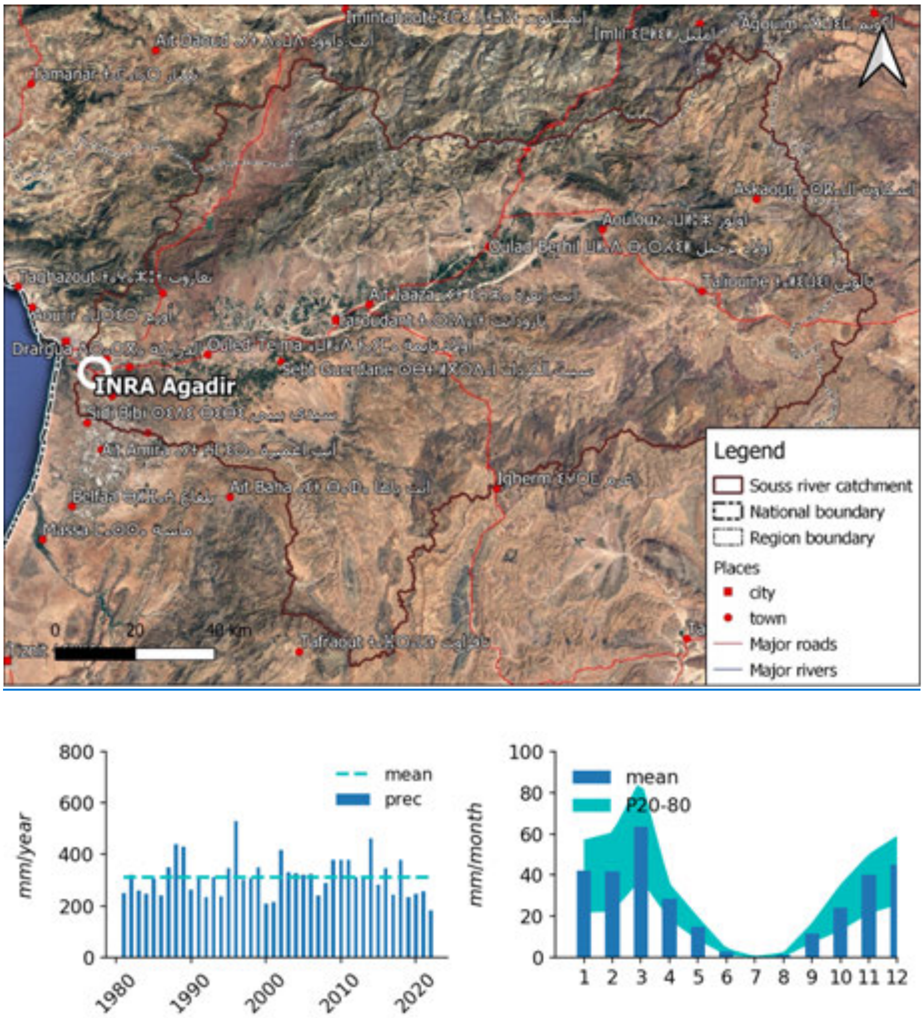
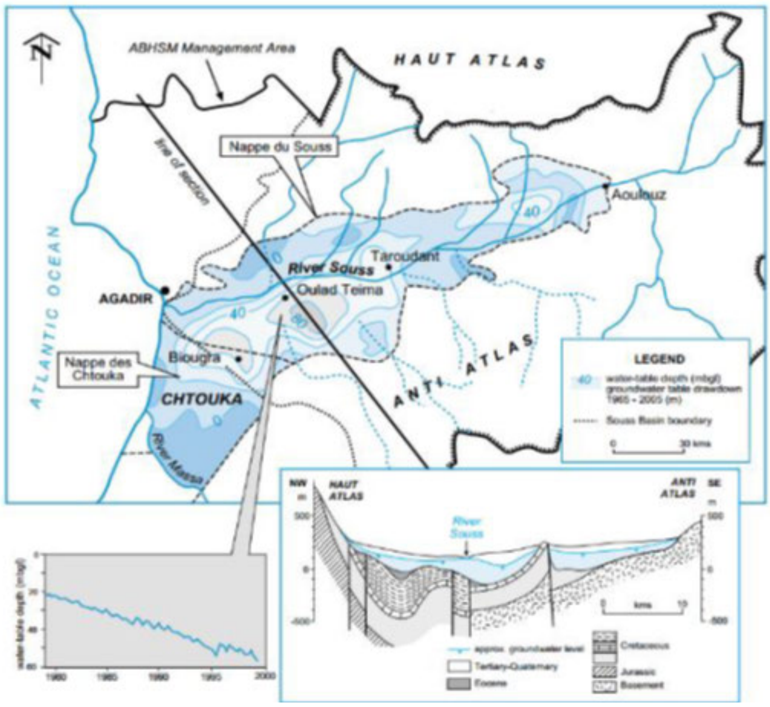


Figure 8. Impression of the Souss Massa area and rainfall over years across Souss Massa catchment. Inside the catchment, a rainfall of 300 mm/y occurs on average, with the wet season stretching from November to May and July and August as the driest months.

Hydrogeology

The Sous valley hosts the Souss aquifer, a groundwater body stretching from Agadir to Aoulouz consisting of recent Plio-Quaternary sediments (sands, gravels, and lacustrine limestone).

The total water use in the basin is approximately 1034 Mm3/year, 36% from surface water and 64% from aquifers, 95% of this quantity is used mainly in agriculture and 5% as drinking and industrial water. Overall, demand for water exceeds the sustainable supply, with the deficit being made up by groundwater overexploitation. Over-pumping of the alluvial aquifer exceeds an average of 284 Mm3/year in Souss aquifer. According to ABHSMD [12], the piezometric level analysis in the Souss-Massa aquifers between 1968 and 2003 shows a reduction in water table level of about 15 m in the Souss upstream, more than 30 m in the middle Souss and 20 m in the Souss downstream.



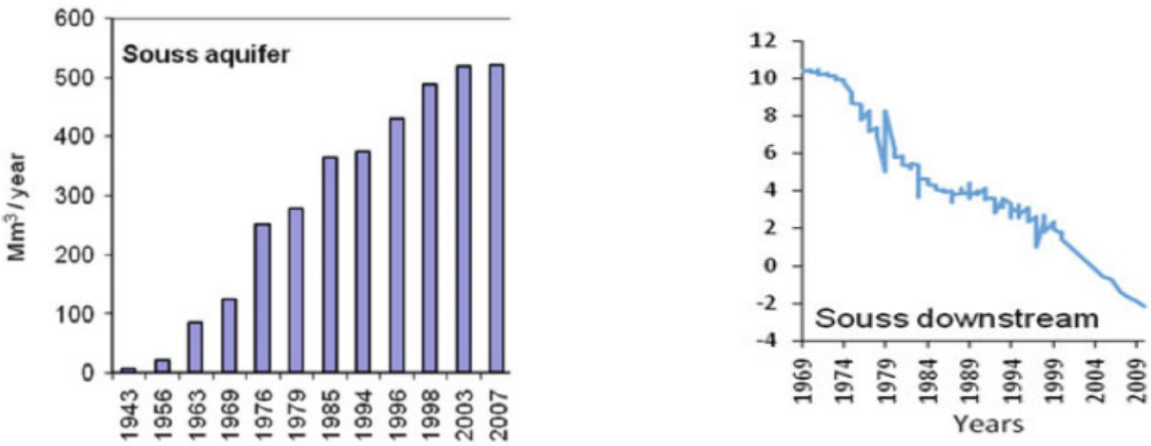


Figure 9. Overexploitation: Pumping rates (left) and groundwater levels (right) in the Souss aquifer.

The water management in the region is severely constrained by:

- Adverse climatic conditions due to Arid climatic conditions and climatic changes
- A large variability of surface water potential from year to year
- A limited groundwater potential
- A high vulnerability to pollution resulting from intensive use of fertilizers and pesticides in agriculture and urban wastewater discharge
- A high water demand caused by rapid population growth and conflicting demand between all sectors
- Vulnerability of the coastal zone to salinization and degradation of several wetlands
- A significant increase in the irrigated land
- Inadequate irrigation of water efficiency

Climate data indicate an overall decrease of precipitation during the three last decades, coupled with an increase of temperature. The depletion of groundwater level induced by limited recharge and overexploitation has induced degradation of water quality in the Souss-Massa plain aquifer (see figure below). The climatic change effect coupled with the pressure of human activities manifested in the intensification of agricultural activities using fertilizers highly affects the water quality with high nitrate contents.
Given the current situation of GW pollution in the Souss-Massa Basin, water-related stakeholders and water users are in need for environmental friendly strategies that are efficient and economically reasonable. Improved sanitation networks and wastewater treatment plants and combined with recycling of solid waste seem obvious to pursue. At farm level, producers can adopt the soilless cropping system especially with a close drainage system which allows to save more water and fertilizers and thus reduces nitrate leaching. It is uncertain whether the desalination of seawater is also a good alternative to reduce the overexploitation of water resources by agriculture.

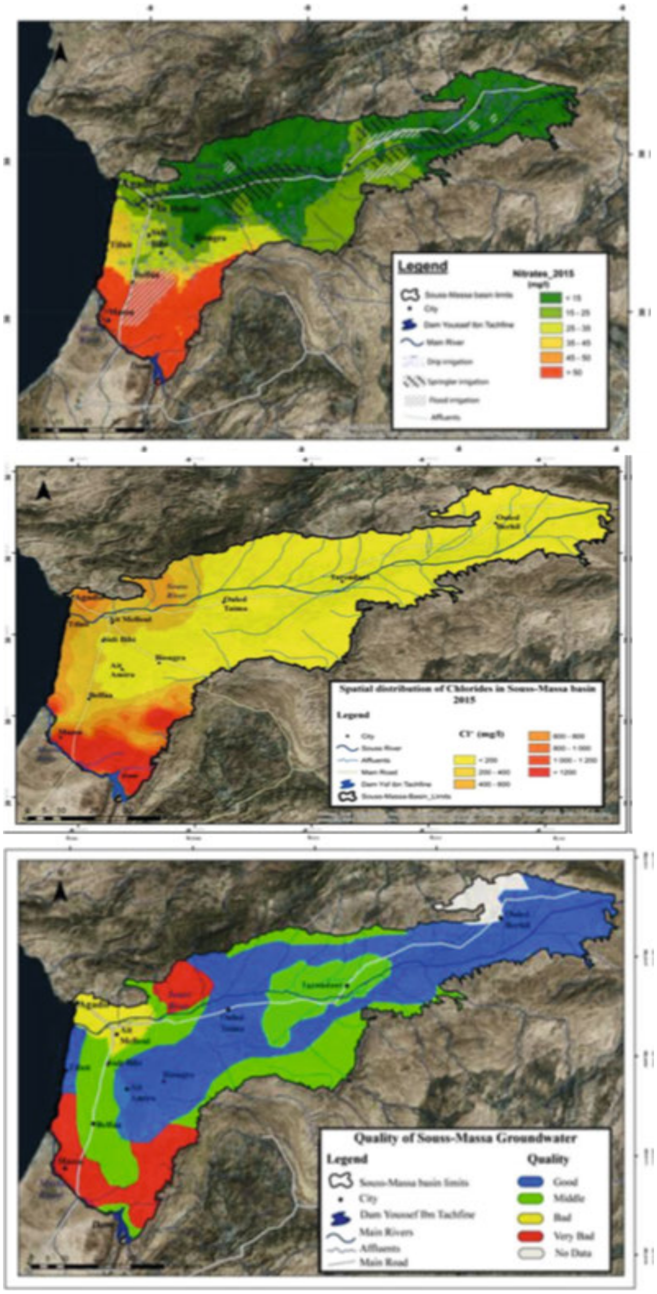


Figure 10. Water quality maps. Nitrate (top, 2015), chlorides (mid, 2015) and general aquifer quality according to the Hydraulic Basin Agency (bottom, 2007).

Visit to INRA's research station

This research station of INRA is 72 hectares in size and a variety of trails are performed here. There are greenhouses ("net-houses") of different sizes and this research includes cactus (Opuntia), tomato, banana and Argan seedlings, among others. The field trials focus on cereals, agroforestry with Argan, but also salinity trials with quinoa and blue panicum are performed here, among others. In this latter trial, also various drip irrigation systems are being tested, with a focus on "micro-pore drip irirgation". Also, irrigation strategies with mulching are taking place. The research on Argan focusses on the challenges and opportunities to create plantations of Argan and how the best seedlings can be created for this. This research is funded by ANDZOA. For the salinity treatment, three concentrations were used. For this, salts are added to the irrigation water to create the different salinity levels. Ground water is used for irrigation, with a salinity level of 1.5 dS/m. According to the Jamal Hallam there are several farms in the neighborhood that have higher salinity levels, especially closer to the coast. In the '90 the groundwater was around 50 meters deep, now they pump water from 200 meters deep. The research focusses on the needs of the farmers of the Souss-Massa region, but also on marginal areas further to the south and east. There is also a research station of INRA in Laayoune that also work on salinity issues. This link, together with the local farmers closer to the coast, doers make this location interesting for further research, validation and demonstration.

The responsible researcher has experience with field trails with salinity and irrigation management and the location is very suitable to conduct (large-scale) field trials. The salinity level of the groundwater is only slightly saline and the majority of the of the field trials focus on non-saline conditions. The knowledge and knowhow and infrastructure to perform a pilot is present. The staff is relatively small and, for a demonstration trial, funding will be needed to ensure the availability of labour. If a salinity trial is to be performed here, various salinity levels can be created by mixing salts with the groundwater. But the research station itself has no issues with (major) salinity.

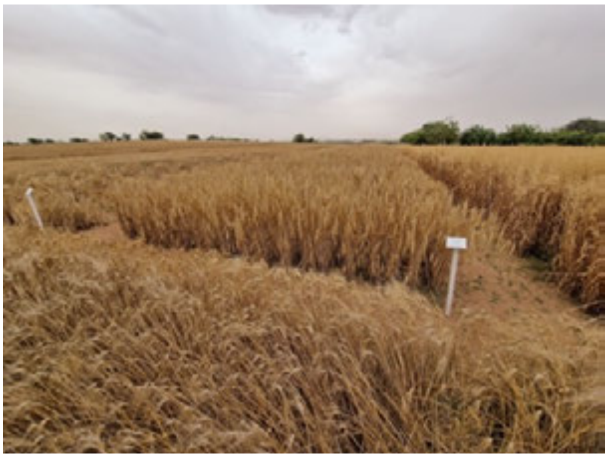



Image 12. Experimental field at INRA-Agadir, with cereal research (left) and Stevia (right) visible here.

Image 13. Experimental field at INRA-Agadir, with Moringa tree (left), and Argan tree (right) visible here.

Image 14. Impression of the salinity trial at INRA Agadir with Blue panicum and quinoa.

Salinity assessment of the visited locations

For the salinity assessment, both irrigation water samples as well as soil samples have been collected and analyzed. The EC has been measured by using a WTW conductivity meter (model 3110). For the soil, mixed sampled were composed by taking around 10 subsamples per location. Where possible, the maximum sampling depth was 30 cm (focus on the active rootzone). Soil samples were dried and sieved (2 mm) before analysis. Soil samples have been analyzed by using the 1:2 method (1 volume part of soil mixed with 2 volume parts of distilled water), the 1:5 method (1 weight part of soil mixed with 5 volume parts of distilled water) and for three samples also the extract of a soil saturated paste was analyzed. The pH and concentration of calcium, sodium and potassium were analyzed using the Horiba Laquatwin sensors and for magnesium the multi io meter of Imacimus was used.

The salinity threshold at which water is generally classified as moderately saline is 1.5 to 3 dS/m. These levels can affect salt sensitive crops and require careful management practices. Water with an Electrical Conductivity (EC) from 3 dS/m up to 7.5 dS/m may cause severe salinity effects. When looking at table 5, the salinity levels of irrigation water that is being used at the visited farms, two can be classified as moderately saline, whereas the other three locations show very high salinity levels.

Table 5. Characteristics of the irrigation water of the visited locations. All location use groundwater for irrigation.

location	EC (in dS/m)	pH	Ca^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)
Errachidia farm	1.8	7.5	310	120	6
UM6P-Farm 1	2.8	7.2	150	440	4
UM6P-irrigated	12.5	7.5	300	2400	14
Oasis 1	14.6	7.1	670	2700	37
Oasis neighbor	8.8-9.2				

So, the use of saline water for irrigation requires careful management practices. This is because the use of saline water can have several potential negative effects, like salt accumulation in the rootzone, a reduction or complete collapse of soil structure and soil fertility, and salt intrusion into freshwater aquifers, among others. A first indication of the soil structure can be obtained by the turbidity (relative clarity of the water phase) of the 1:5 method (see image 15). If the soil aggregates are still intact then these soil particle will settle at the bottom of the beaker and the water phase will be relatively clear. This is an indication of good soil structure. When the water is not clear then this is an indication of poor soil structure. Based on image 15 the two samples on the left (UM6P, irrigated and non-irrigated) show the least transparency due to suspended particles, with the non-irrigated soil sample showing the least clarity. But, in general, there seems to be little concern for the soil structure of the visited locations, although this should be validated based on lab analysis (which has been done for the soil samples UM6P-irrigated and a mix of the two soil samples from the oasis). It should be noted that this effect of turbidity is mostly linked to clay soil, so sandy soils in general don't show this effect.

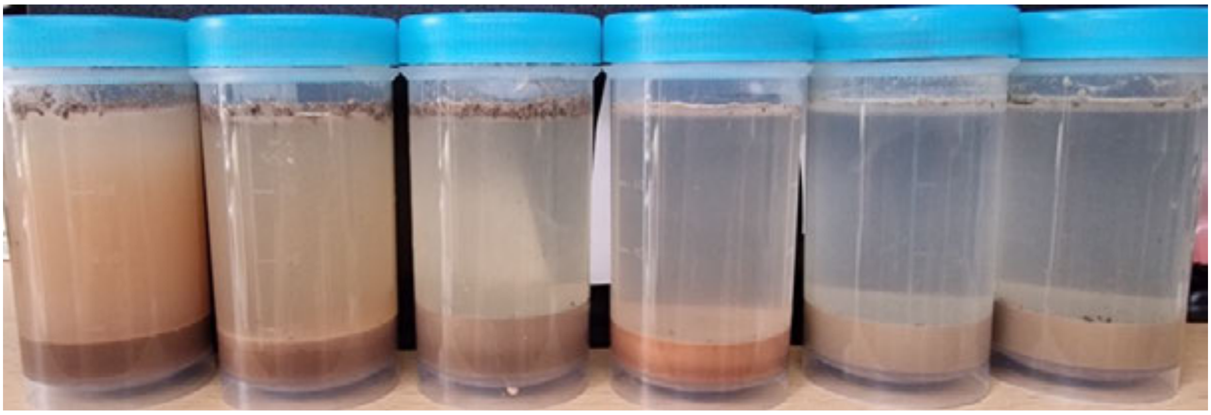


Image 15. Impression of the stability of the soil structure, based on the turbidity of the water phase of the 1:5 method, with the samples UM6P-non irrigated, UM6P-irrigated, dry lake, Errachidia farm, oasis 1 and oasis 2 visible from left to right, respectively.

The results of the salinity measurements of the soil samples are given in table 6. For the first oasis farm that was visited, two samples of different parts of the farm was sampled (oasis 1 and 2). No soil sample was taken at the other oasis farm (sample "oasis neighbor" in table 5 for the water analysis). The two soil samples of the oasis farm were also mixed and analyzed and this mixed sample has also been send to the lab for detailed analysis. As indicated before, the soil sample of the "dry lake" was also collected in the plane of Sed Masjoun (in the area of UM6P).

Table 6. Results of the different analysis of soil electrical conductivity (in dS/m), and determined by the methods of 1:2 (v:v), 1:5 (w/v) and the extract of a soil saturated paste (ECe; measured directly for 3 samples and calculated for the other samples). The pH was measured in the extract of the soil saturated paste.

Sample	EC 1:2	EC 1:5	ECe	ECe calc.	pH
Oasis 1	9.1	3.7		21.8[1]	
Oasis 2	5.3	2.1		12.7[1]	
Oasis mix	7.3	2.9	17.6		7.8
UM6P- irrigated	4.6	1.6	16.3		7.6
UM6P- non irri	0.6	0.3	2.0		8.0
Dry lake	5.2	2.2		12.5[2]	
Errachidia farm	1.3	0.6		4.6[3]	

[1] > a factor of 2.4 was used to calculate ECe from EC 1:2 (based on sample "oasis mix)
[2] > sample "dry lake" seems to be rich in clay, as is "oasis", so also here a factor of 2.4 was used to calculate ECe
[3] > this sample is more sandy, a factor of 3.5 was used to calculate ECe, but this factor needs to be validated

The overall EC of a given sample is the sum of the four major cations sodium, calcium potassium and magnesium. Since the different cations have a different effect of plant growth and the stability of the soil structure, it is important to understand which cation is responsible for the elevated EC (salinity) levels. The concentrations of the four cations of the different extracts (either the extract from the soil saturated paste (SP) or the 1:5) are given in table 7. In fact, the sum of these four cations (expressed in milli-equivalents per liter (meq/L), divided by ten, provides the EC of that solution. This data is provided in table 8. Also, the data of the SAR and CROSS values are presented in this table. The SAR and CROSS values provide an indication of the stability of the soil structure. In shorty, a value greater than 13 (for SAR) can potentially result in poor soil structure. It is best to assess this for the extract of the soil saturated paste, which has been done for three soil samples. Since the saline irrigation water is dominated by sodium, the SAR values of the soil show a high value (21 and 24 for "oasis mix" and "UM6P-irrigated" respectively). So, these high SAR values can indicate issues with soil structure, although a high EC value of the soil often reduces this potential problem. Based on image 15 the soil aggregates seem to be stable.

Table 7. Cation concentrations (in mg/L) of the different extracts of the soil samples. Extracts were either obtained from the soil saturated paste (SP) or according to the 1:5 method.

Sample	extract	Na^+	Ca^{2+}	K^+	Mg^{2+}
Oasis mix	SP	2800	490	74	526
UM6P- irrigated	SP	2800	730	55	181
UM6P- non irri	SP	110	332	13	31
Oase mix	1:5	430	180	19	38
UM6P- irrigated	1:5	340	68	7	4
UM6P- non irri	1:5	14	73	4	3
Oasis 1	1:5	520	230	15	52
Oasis 2	1:5	310	120	21	30
Dry lake	1:5	420	98	15	10
Errachidia farm	1:5	26	120	2	9

Table 8. Cations (in meq/L), ECe (* in dS/m, data from table 6), pH, SAR and CROSS data of the different extracts of the soil samples.

Sample	extract	Na^+	Ca^{2+}	K^+	Mg^{2+}	EC*	pH	SAR	CROSS
Oasis mix	SP	122	25	1.9	43	17.6	7.8	21	25
UM6P- irrigated	SP	122	36	1.4	15	16.3	7.6	24	26
UM6P- non irri	SP	5	17	0.3	2.6	2.0	8.0	1.5	1.7
Oasis mix	1:5	19	9	0.5	3	2.9	7.9	7.6	8.1
UM6P- irrigated	1:5	15	3.4	0.2	0.3	1.6	7.8	11	11
UM6P- non irri	1:5	0.6	3.6	0.1	0.3	0.3	7.9	0.4	0.5
Oasis 1	1:5	23	12	0.4	4.3	3.7	7.9	8.1	8.6
Oasis 2	1:5	14	6	0.4	2.5	2.1	7.9	6.6	7.1
Dry lake	1:5	18	5	0.4	0.8	2.2	7.8	11	11
Errachidia farm	1:5	1.1	6	0.1	0.7	0.6	8.0	0.6	0.6

As said, a sample of "oasis mix" and "UM6P-irrigated" has been sent to the lab for detailed analysis. Some of these results are presented in table 9 and 10. In table 9 the percentages of clay, silt and sand are given, based on which the soil type can be classified. Also, the soil organic matter content and pH is provided. So, "oasis mix" can be classified as a sandy loam soil with low organic matter (0.6%) and very high pH. The pH that was obtained from the extract of the saturated paste (table 6 and 8) was considerably lower (pH 7.8) and the result from the lab (table 9) are more representative for the actual field condition. A pH greater than 7.8 is considered as "high" (see table 2) and a pH of 8.5 can have great effect on the availability of various nutrients in the soil. Besides the high pH also the low organic matter content of the soil should be noted. Increasing the soil organic matter content can have a positive effect on several soil aspects. At the location "UM6P-irrigated" the soil is much richer in clay and silt and can be classified as loan. The soil organic matter content is much higher (2.4%) and pH is also relatively high.

Table 9. Some soil characteristics of the 2 sampled locations, based on laboratory analysis performed by Eurofins (Netherlands)

Location	**Clay (%)**	**Silt (%)**	**Sand (%)**	**Carbonate lime (%)**	**Soil type**	**Organic matter (%)**	**pH**
Oasis mix	7	15	64	13.1	sandy loam	0.6	8.5
UM6P-irrigated	20	43	234	0.4	loam	2.4	8.0

In table q10 the results of the different aspecyts of the clay humus complex are provided. The overall clay humus result (in mmol⁺/kg) is low for the sample oasis mix (due to low percentage of clay and organic matter. As can be seen for the target values, a good soil structure comes from high saturation percentages of calcium (80-90%) and magnesium can also be present (optimal values between 6 and 10%). Due to salinity often the saturation percentages of not only sodium but also magnesium are often high, resulting in sub-optimal to poor soil structure. Based on the results in table 10 it seems that soil structure is moderate for oasis mix (mainly due to low calcium and high magnesium) and for "UM6P-irrigated" the soil structure is good to optimal even though sodium saturation is relatively high.

Table 10. Characteristics of the clay humus complex, including the saturation percentages of the different cations and the status of the overall soil structure.

	Oasis mix		UM6P-irrigated	
	result	target value	result	target value
Clay-humus (CEC) (mmol⁺/kg)	30	>49	155	>127
Ca saturation (%)	72	80-90	87	80-90
Mg saturation (%)	22	6.0-10	7.3	6.0-10
K saturation (%)	3.3	2.0-5.0	<0.1	2.0-5.0
Na saturation (%)	3.3	1.0-1.5	5.6	1.0-1.5
Soil structure	moderate		good / optimal	

Suitability of visited location to conduct a first field trial

The suitability of a given location for conduction potential pilots depends on several factors. To start, the salinity concentrations have to be in a specific range in order to conduct relevant trials. In practice this means that the salinity levels should not be too low (< 4 dS/m, ECe) but also not too high (>10-12 dS/m), since this can result in a large restriction regarding the crop options. Based on the irrigation water and soil salinity levels the location "Errachidia farm" and "Oasis neighbor" seem to be the best options for a pilot. The relevance of a location is also important. For instance, the "Errachidia farm" is located in an area with some other farms, but the area itself is not widely used for agriculture. This implies that the location is not representative for a much larger area. The "oasis" locations do represent a much larger area, so conducting a pilot somewhere in the oasis seems to make sense. The oasis ecosystem represents around 32% of the agriculture in Morocco, so this makes this ecosystem highly relevant. The extreme salinity levels of the irrigation water and the soil of "oasis 1-2-mix" does restrict the options for irrigation and crop selection, especially in comparison with "oasis-neighbor". At this "oasis-neighbor" locations, the irrigation water salinity levels are much lower and the fact that alfalfa is cultivated successfully here also indicates that soil salinity levels are considerably lower than at "oasis 1-2, mix". But the soil salinity levels between "oasis 1" and "oasis 2" show considerable differences (both samples were collected at the same farm but form two different plots) and this indicates that even at "oasis 1, 2-mix" there might be some plots that provide options for a pilot with some additional crops. Additionally, a suitable location also depends on the willingness of the farmer. It should be checked which farmer is interested in participating in a pilot that will include data collection and close monitoring by the farmer. Also, it is often of added value if a location is in close vicinity of the local institute that will participate in the pilot. In short, the overall oasis ecosystem is suitable for conducting a pilot, but it is recommended to perform a more detailed analysis at the various oasis farms to select a location that is ideal to perform a pilot.

The area around the UM6P University in Ben Guerir also shows potential for a pilot. The area is widely used for agriculture and many farms are salt affected here, which makes a pilot highly relevant. The experimental fields of UM6P itself are not salt-affected, so this would not be the first option for a pilot. UM6P does have the ambition of setting uop an experimental farm in the salt-affected area that was visited. Their first option for a location is a farm that is abandoned at present. The existing well only provides highly saline water which makes it necessary to install a second well that could provide low salinity water (>230 m). With additional equipment it is possible to mix the low and high salinity water into different salinity levels for controlled testing. However, this is a relative large investment, which makes this option not ideal for a quick pilot. So, conducting a first pilot at one of the existing farms seems to make more sense. Based on table 5 and 6 the location "UM6P-irrigated" is highly salt-affected and seems to be somewhat limited for conducting a pilot with various crops. One of the other sampled farms (only the irrigation water was analyzed; "UM6P-Farm 1" in table 5) shows much lower salinity levels. In short, the conclusion for this area is the same as for the oasis system: high relevance, but additional research is needed to identify the best location in this area.

The pilots itself can focus on soil and water management and showcasing and validating the crop performance of previously identified salt tolerant varieties, but it can also include an innovative way of crop cultivation like open-field hydroponics. This system has been developed and tested in the Netherlands already, and it has also been validated in Tunisia, under comparable conditions as in Morocco. This approach can be very interesting as a business model during the first years of setting up a date palm or lobe tree orchard, since it will take several years before the farmers get any revenue from the growing trees. Also, during the visit it was highlighted several times that farmers are interested in cash crops with good market potential. This hydroponic system is suitable for the cultivation of a wide variety of crops like cauliflower, tomato, cabbage, (spinach) beet and lettuce and most of these crops have a good market potential in many locations. It also has the benefit of being able to use saline water, without the need of controlled leaching and drainage. So, this is a relative low tech system which is easy to apply by farmers.

Potential crops for pilot

In table 11 an overview is provided of proven crops under saline conditions. The overview includes the yield potential (in tons per hectare) that can vary widely due to climatic conditions and cultivation practices. Also, the growth period (in days after (trans)planting until harvest) and the maximum salinity level (ECe, in dS/m as well as in ppm) for optimal yield (90-100% yield compared to non-saline conditions) is provided as well. The maximum salinity levels for an economic viable yield is even higher but the exact level will depend on several factors that include the costs and the benefits. So, these crops have been tested by The Salt Doctors (in the Netherlands) under controlled field conditions and the yield performance is validated in several countries (Tunisia, Egypt, Jordan, Bangladesh, among others). Crops from this list can be introduced quickly for a pilot and upscaling is possible if needed.

Table 11. Overview of some potential crop based on the work of The Salt Doctors, to be used in a pilot in Morocco.

	Crop	Family	yield potential range (ton/ha)	harvest in days after (trans)planting	ECe (in dS/m) max for optimal yield	ECe (in ppm*) max for optimal yield
proven crops	Salicornia	Amaranthceae	20-60	50-90	20	16000
	beetroot (red beet)	Amaranthceae	25-35	60-80	12	9600
	chard ("spinach beet")	Amaranthceae	10-40	30-40	12	9600
	sugar beet	Amaranthceae	40-80	150-200	12	9600
	potato	Solanaceae	30-60	100-120	8	6400
	carrot	Apiaceae	20-70	90-120	8	6400
	cauliflower	Brassicaceae	20-40	60-80	6	4800
	pakchoi	Brassicaceae	30-50	25-30	6	4800
	lettuce	Asteraceae	24000 (heads/ha)	30	6	4800
	cabbage	Brassicaceae	40-60	50-70	4	2560
	onion	Amaryllidaceae	20-40	80-110	4	2560

Conclusions and recommendations

Conclusions and recommendations for short term

- Many locations use open water reservoirs. This will result in 20-25% water loss due to evaporation. It is recommended to cover these open water reservoirs (shade net, floating cover on top of thew water) and/or place wind breakers around the reservoirs in order to reduce evaporation. Also, the shape of the reservoir can be altered in the future to reduce evaporation (deeper reservoirs with less exposed surface area).
- Various locations use flood irrigation. Although this can be a relative efficient way to leach salts below the rootzone, this type of irrigation uses much more water than drip irrigation. Switching to drip irrigation, or sub-surface (micro-)drip irrigation will increase the water use efficiency.
- The use of (organic) mulch (the straw of cereals is very effective) or cover crops can reduce the soil temperature and the water loss from the soil via evaporation. This can further improve the water use efficiency and improve crop yield under saline conditions.
- The use of organic mulch and cover crops will also increase the soil organic matter content. At the sampled location in the oasis, soil organic matter is only 0.6%, so increasing the organic matter content is very important. A higher organic matter content will also improve the water holding capacity, further improving the water use efficiency.
- Many farmers are often not aware of the optimal leaching requirement and the drainage capacity of the soil. Improved irrigation management can improve soil salinity conditions and optimize water use.
- The soil pH of the samples two locations that were send to the lab were 8.0 and 8.5. These high pH levels will affect plant growth and nutrient availability. Using mineral fertilizers that lower soil pH can be an option, as well as improving the micro-climate around the roots (improve soil fertility (by means of organic matter) and using foliar fertilizers can improve plant growth and crop yield.
- Both water and soil salinity levels can be classified as very strongly to extreme saline conditions. These salinity levels will restrict the cropping options. For a demonstration (with a variety of conventional crops) on the short term, it is recommended to focus on locations with lower salinity levels.
- The agricultural production and water management in all four areas face increasing number of challenges with regard lowering water quality (mainly salinity) and overexploitation of the remaining ground and surface water. For example, in Agadir, the only water sources are groundwater or use of Souss river directly, although the latter poses difficulties. Groundwater is increasingly being overexploited while gernal water quality is lowering. Focus should be both on more efficient water use and methods to deal with increasing salinity. As such, climate smart irrigation, drip irrigation (subsurface and/or moist tubes) and (open field) hydroponics seem to have good potential. Rainfall is too low for rainwater harvesting, and while some 3R measures would be good for preserving Souss aquifer, as a whole they are not suited at plot scale at the target site. The site is viable for piloting alternative crops or saline farming (also because of saltwater intrusion) seems an opportune alternative, while it may be a prime candidate for the use of treated waste water as Agadir is a very large city with a significant waste problem.

- In the Ziz oasis and basin, brackish water is becoming more abundant. The area would be a prime candidate for piloting some scheme that deals with alternative agriculture under brackish conditions, while increasing water use efficiency can also provide substantial benefits to the oasis area.
- In Sed Hashoum, the situation seems to offer the least potential; low rainfall and limited catchment area result in few renewable water resources. Most current agriculture seems based on diminishing fossil sources, with high salinity becoming more and more prevalent. Increasing water use efficiency and saline farming methods would be beneficial in this area, although it may not be enough to counter the diminishing supplies. The main way this location is more promising than the others is its potential for water storage options; with slightly higher rainfall and more decentralized flow of water, water capture through 3R interventions has some potential here.
- Of the visited locations the area of the oasis ecosystem and the area around Agadir seem to show the best potential for a pilot on the short term. This is based on the current available infrastructure, the observed salinity levels, the potential of using the pilot for potential upscaling and the water availability. It is known that in these areas' locations are present with moderate to strongly saline conditions which make these locations suitable for the crops that have been tested and validated under saline conditions before. However, most of the visited location so far are often not ideal (regarding observed salinity levels) and other locations in these areas must be visited to identify the best locations. This can take place as a first phase of the demonstration and no major problems are foreseen to identify these locations quickly.
- The use of magnesium containing fertilizers should be avoided at the "oasis mix" location due to high magnesium saturation in the clay-humus complex, which already has a negative effect of the soil structure.
- It is recommended to include all the above-mentioned points in the intended pilot.

Leads for follow up

- A low-tech, low-cost open field hydroponic system has been validated by The Salt Doctors in Tunisia. This system has great potential for water scarce and salt affected areas and there was a lot of interest among the stakeholders about this system. This system can be included in a demonstration in Morocco as well.
- Intercropping and agro-foresty are also very suitable for water scarce and saline conditions. The options for integrating these approaches in future activities should be explored further.
- It was observed that large differences occur in the salinity levels of different wells, even the wells that are located relatively close together. This implies that the quality of the groundwater can vary at different depths and also "horizontal" variation may occurs at the same depth. More insight is needed in the groundwater distribution before wells are drilled and also the casing of the wells, to prevent water from different layers entering the well, seems to be very important. These activities can be performed by Acacia Water if desired.
- Many wells seem to be located in areas with very limited recharge. New agronomic activities should focus on areas with proper recharge to ensure the sustainable use of the groundwater reservoirs. Under specific conditions also saline groundwater can be used, but also in this case the use should be sustainable and increasing salinity levels due to over extraction must be avoided. Identifying the most suitable locations from a sustainable water point of view can be performed by Acacia Water.

- UM6P has the intention to cooperate with the Dutch partners at the location at Ben Guerir and Laayoune. The location at Laayoune has a focus on saline agriculture, but it is located in the south of Morocco which limits the potential involvement of the Dutch government at this point. Direct cooperation of the Dutch partners is possible and potential cooperation is explored. The ambitions of UM6P at Ben Guerir will take a considerable investment. The potential for cooperation here will be explored further.
- All involved stakeholders are keen to cooperate and research and validate the performance of salt tolerant crops, climate-smart farming practices and improved water management. More specifically, INRA has budget within the Generation Green 2020-2030 program that can be used to cover the expenses of INRA. If additional funding can be identified for the Dutch partners then there seems to be a good opportunity to start a demonstration trial on relative short notice. Options for this cooperation should be explored further.

Focus on potential demonstration project

Based on the outcomes of the field measurements, the validated observations and the numerous discussions with key governmental and academic institutes and organizations as well as a representative group of different farmers across the area, we can now narrow down on an overview with important opportunities to consider for setting up a most promising demonstration with the joint involvement of academic, governmental and other public and private parties from Morocco and the Netherlands. Here, we used a similar methodology as explained by Langenberg *et al*. (2021, link). Opportunities are weighed and color-coded for each location according as well to the demand and need, and likelihood of success (i.e., scalability and impact) of the proposed demonstrations.

Table 12. Various opportunities, associated technological expertise, and applicable knowledge in the areas visited. Colors indicate the likelihood of successful Dutch-Moroccan demo-ing and consequent entrepreneurship thereafter. Blue: Clear demand, Grey: Likely demand, Orange: Medium chance, but uncertain and Red: Little to No support (legend below).

Opportunities	Specific technology	Agadir	Errachidia	Erfoud	Ben Guerir
Waterefficient technologies	1. Climate smart irrigation	Blue	Blue	Blue	Grey
	2. Drip irrigation	Grey	Grey	Grey	Orange
	3. Crops under greenhouses	Blue	Grey	Orange	Orange
	4. Hydroponics	Blue	Grey	Grey	Grey
Smart water capturing	5. Rainwater harvesting	Orange	Red	Red	Red
	6. Dew yield	Red	Red	Red	Red
Catchment interventions	7. 3R approach	Grey	Orange	Orange	Grey
	8. Protection, restoration, management	Blue	Blue	Grey	Orange
	9. Soil and water conservation (SWC)	Blue	Blue	Grey	Grey
	10. Off-stream water storage	Grey	Grey	Grey	Orange
	11. In-stream water storage	Grey	Blue	Blue	Red
	12. Managed aquifer recharge	Grey	Grey	Grey	Red
Capacity building & skills	13. Bridging the knowledge gap	Blue	Grey	Grey	Red
	14. Digitalization, geo-data, satellite	Blue	Blue	Blue	Orange
	15. Good local partner	Blue	Grey	Grey	Orange
	16. Improve post-harvest processes	Grey	Grey	Grey	Orange
Innovations	17. Salt tolerant crops	Blue	Grey	Blue	Blue
	18. New tolerant cash crop types	Grey	Grey	Orange	Orange
	19. Solar energy in agriculture	Blue	Blue	Grey	Grey
Using non conventional water resources	20. Saline farming	Blue	Blue	Blue	Blue
	21. Desalinized water	Blue	Orange	Orange	Grey
	22. Treated waste water	Red	Orange	Orange	Orange

Blue	Clear demand for Morocco - Netherlands partnership support.
Grey	Likely demand for Dutch expertise.

	Medium chance, but uncertain.
	Little to No support.

Creating business enabling environment

The various fields of opportunity and technology specifics with regard to sustainable water-agri (Table above) assist in creating a business-enabling environment, remove barriers and find common ground for matching local and Dutch business and knowledge partners. This mission showed that opportunities in particular lie in water-efficient technology, integrated interventions at location, salt tolerant crops, saline farming and other innovations (3R, solar, hydroponics).

Weighing the outcomes of this mission and the results of recent Maghreb study (Langenberg *et al.*, 2021) we conclude the highest demand– and likely the green business potential- for a practical and exemplary demo of Moroccan and Dutch techniques and knowledge combined to be at Agadir and Errachidia.

There- through scalable business set ups- we can develop the horticulture (vegetable) sector at Agadir and Errachidia by providing smallholder, medium scale and a few large-scale farmers access to quality input materials and practical knowledge on high quality hybrid (salt tolerant) seeds, open field hydroponics, water infra structure and 3R management, in-field monitoring equipment, water agrovoltaic production and water storage setups, and high quality seedling production, fertilizers and (biological) crop protection, but also aspects of agroforestry have good potential (as part of the "innovation" aspects (new tolerant crop types and cropping systems).

We suggest focussing first on the demonstration of:

- Introduction of salt tolerant varieties of conventional (vegetable) crops
- In combination with soil improving cropping systems (increase water retention and soil fertility)
- Water saving, nature-based solutions like the use of (organic) mulching, cover crops and agroforestry (in combination with the salt tolerant annual cash crops). This will reduce evapotranspiration and thus safe water (reductions in water use up to 50% should be possible, in combination with adjusting the existing water reservoirs)
- Improving irrigation management under saline conditions (leaching and drainage) to prevent salt accumulation and soil degradation
- Open-field hydroponic system that uses saline water for vegetable production (robust, easy-to-use, low-cost system)

These activities will be embedded in both an ecosystem-based and an integrated water resource management approach and will also link several stakeholders to ensure their engagement and commitment for the next phase.

Besides providing access to the needed applications and specific fit-for-a-purpose technology we aim with our business setups at Agadir and Errachidia to transfer and co-develop knowledge on the inclusive benefits of using quality input materials and train farmers and stakeholders in how to farm while using Good Agricultural Practices (capacity building) in a salinizing environment where managed water resources is the basis for sustained production. We will also help connecting smallholders and medium scale farmers to off-takers and financiers so it will become easier for these famers to invest in more viable water-agri setup that they can scale and professionalize, even at the suggested locations.

From trials and pilots in similar North Africa's regions we have proven that with new input materials, improved cropping systems and capacity building, the yields of farmers will increase, diversify away from water sensitive crops and fruits while the quality of their products will improve, allowing them to ask higher prices for their produce and slowly restore the over-exploited water and soil resources.

The demos are further described below.

Short description of the proposed Business DEMOs

Demo objective:
The establishment of two DEMOs where most opportune and selected water management and horticultural technologies are demonstrated in a real-live context (saline agriculture), with a specific focus on scalable horticulture/agroforestry business generation.

Project summary:
The experience DEMOs will form the platform for validating and showcasing resilient cropping systems and improved water resource management, vocational training and awareness raising activities and will at the same time serve as the commercial showcase of (The Salt Doctors, Acacia Water, Delphy, WUR, Eijkelkamp and local partners like INRA and ANDZOA) with the private sector (agriculture, agri- and water-business) as key focus clients. At this stage a cooperation with organizations like INRA and ANDZOA is the best way to develop and implement a demonstration project (1 year project) on short notice. This demonstration can subsequently be used to engage the private sector to ensure their commitment in a second stage (3-4 year project).

In the light of increasing agricultural activities in the selected arid areas (coastal zone and oasis), there is a significant risk that these activities will lead to a further degrading of the ecosystem, due to uncontrolled ground water extraction and unsustainable agricultural practices. This is likely caused by a lack of knowledge and the lack of capital to invest. What we want to prove with the business demos, is that there are scalable, low costs, practical and climate smart solutions available for farmers that can both increase their income as well as improve the quality of the soil, the water and the ecosystem in general.

We intend to work together with companies, governmental bodies and knowledge institutes for setting up the demos where more sustainable growing techniques will be demonstrated, and where more suitable crops (climate change and salt resilient) will be grown. Complementing climate resilient cropping systems with sustainable water management technology will thus create a firm base or platform where farmers and other stakeholders can gain practical insights into how to manage their agribusinesses in a more sustainable way.

Project measures:
The project measures below (phase 1, 2 and 3) provide an overview of a multi-year approach to ensure effective results. Most likely, it is advisable to start with a demonstration (phase 1), together with organizations like INRA and ANDZOA, to create awareness among different stakeholders (especially the private sector) and showcase the possibilities from an ecologic and economic point of view, before farmers are willing to participate and invest.

Phase 1: creating a demonstration environment
In the setting of the demos, we will show various technological solutions that will contribute to resilient cropping systems and improved water resources management. This links to the four main 3R intervention groups as presented in the previous mentioned "Maghreb" report (link). of which:

1. Soil and water conservation (SWC) and vegetative protection and restoration measures will be combined (e.g., through swales, resilient cropping systems (based on agro-ecology and agroforestry), reforestation, farmer managed natural regeneration (FMNR), or contour trenches, wind breakers and bunds);
2. Implementation of several types of water storage facilities (e.g., water storage ponds, water tanks or a shallow or deep borehole with recharge facility);
3. Implementation of several types of storage facilities (e.g., dam, subsurface infiltration; whilst
4. Demonstration of open-field hydroponic cultivation and other durable technologies (e.g. water monitoring sensors, soil sensors, solar pumps and various types of piping and supply solutions).

The most suitable solutions will be put into operation in such a way that they are suitable for practical training purposes. Various implementation stages have been identified in setting up a "resilient cropping system" project, based on an integrated development process:

a) **Facts:** Development of a knowledge base, including analysis of the local biophysical context;
b) **Dialogue:** local partner engagement, and further consultation and sensing of wishes, needs and potential synergies;
c) **Strategies:** drafting and evaluation of initial designs and budgets, and creating support for ideas and (financial) commitment of local stakeholders;
d) **Implementation:** implementation of short and long-term interventions at demo sites, with support from- and adopted by local partners.

This is an iterative process that can repeat and improve itself under changing circumstances (see Figure *1*) The proposed integrated and iterative build up process will ensure that local partners and communities can and will adopt better the 3R approach, so that they too become part of and benefit more from the improved agro-business model.

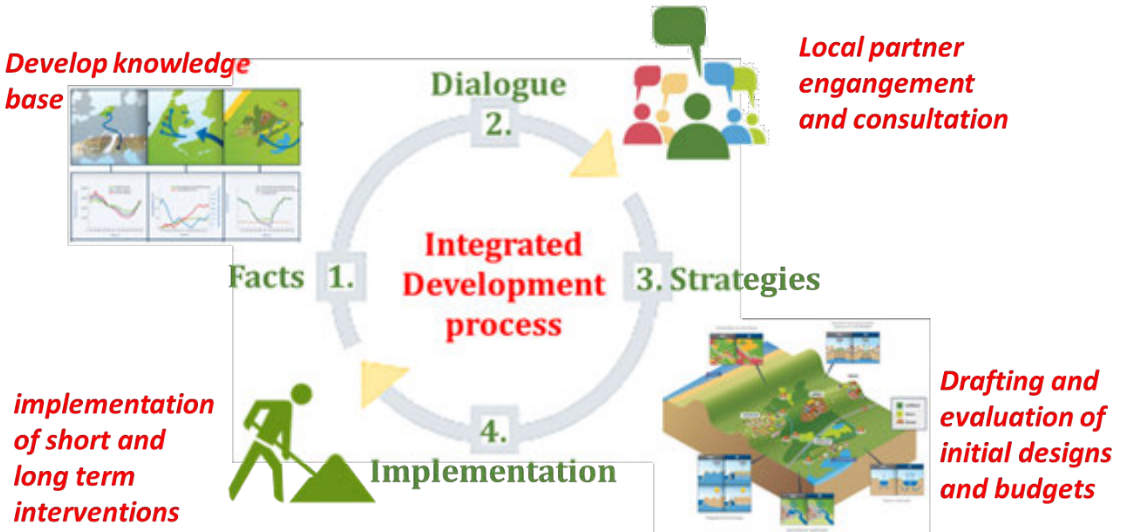


Figure 11. Proposed integrated and iterative development process for implementation of 3R interventions

Phase 2: develop the training tools for water resources management and resilient cropping systems under marginal and saline conditions

As we intend to maximize knowledge sharing via practical training and demonstrations, we will create:

5. A training facility
6. Training documentation (English and French)
7. A Training of Trainers programme (10 trainers trained)
8. A database of farmers, local investors and other stakeholders that have a vested interest in horticulture and water resources management in dry and or salinized lands.

Furthermore, as we believe that semi-arid areas would greatly benefit from resilient cropping systems practices in contrast to current non-perennial cropping practices (often with crops that are not suitable with regards to the climatic conditions), we want to demonstrate our water management solutions in combination with a demonstration of agroforestry and agro-ecology methods:

9. Demonstrate the concept of agroforestry and agro-ecology: combining drought resistant trees (timber, fruit, seeds), covers crops and intercropping that also reduce erosion and soil degradation, in combination with shrubs, legumes and vegetables. This approach will increase soil organic matter (which is directly linked to improving soil fertility, improving water retention, reduce irrigation need and also acts as "carbon farming") and increase crop yield and farmer's income as well.
10. Develop a tool where farmers can decide on which combination would work best for them, including financial analysis, market information and growing requirements.
11. Training documentation on resilient farming systems (including organic growing methods)
12. Training of Trainers programme
13. Setting up of a nursery that will provide farmers with high quality seedlings (tree seedlings, vegetable seedlings)
14. Demonstrating low-cost participatory monitoring practices so farmers can follow and act upon production, water and environmental status and trends.

Phase 3: dissemination and extension services

15. Promote the experience centre to the target groups via social media, (free) publicity and partnerships with various stakeholders.
16. Organise training programmes for various target groups, such as youth and women (ranging from farmer field days to individual training)
17. Create an extension service whereby after the training the various target groups receive ongoing advice (farm visits, whatsapp groups, by phone and email). This could be organized in close collaboration with partner governmental bodies.
18. Set up a monitoring and evaluation system where the impact of the training and knowledge sharing is tracked and evaluated.
19. Organise a dissemination campaign with the partners.

The target groups of this project proposal are:

1. SME Farmers and farmer groups at Agadir and Errachidia. We aim to train 1000 farmers and include follow up visits by our trainers (we expect an uptake of 30% of farmers trained that will put it into practice and need further support). The training of the SME farmers and their staff will be free of charge. Specific target groups will be youth and women, whereby also "2 generations" farms, will be included (where the children are preparing to take over from their parents).

2. Large scale investors in agribusiness (50): All partners in collaboration will seek to assist these investors in making their operations more sustainable and more profitable. Project development and -improvement services will be charged at a commercial fee.
3. NGO's and financial institutions that are interested can participate in training activities at our Demo sites.
4. Suppliers of farm inputs and technologies may be interested to showcase their products and services at the demo sites.
5. We would also like to give some training at local schools in the area and assist them in setting up small-scale agroforestry activities at the schools, including water efficiency, 3R approaches and other water management solutions.

Potential partners involved:

Name	**Place**	**Field of Activity**	**Tasks**
Netherlands			
The Salt Doctors	Netherlands	Improving crop yield under saline conditions	Introducing salt tolerant crops and resilient farming systems, including open-field hydroponics
Acacia Water B.V.	Netherlands	Sustainable Water Management Solutions	Designing appropriate "3R" solutions, supervising the construction, designing the training material (3R), giving training (3R), giving advice 3R)
WUR	Netherlands	Overall food system and education	Analysis of whole value chain in relation to food system, provide education
Eijkelkamp	Netherlands	Supplier of agricultural equipment	Assess which equipment is needed and ensure availability and proper functioning of (digital) tools
Delphy	Netherlands	Knowledge provider on climate smart agriculture	Assist with development and implementation of resilient cropping systems, in relation to climate smart agriculture and good agricultural practices
Morocco			
INRA	Rabat / Agadir	Agroforestry (e.g. Intercropping date palms)	R&D with target farmer groups. Monitoring practices soil and water.
ABH	Guir-Ziz	Water management	Geohydrology and other innovative approaches in relation to drinking water and agriculture
ANDZOA	Erfoud	Integrated research tech- socioeconomy	Training broad and also IWRM, Mitigation of salinity challenges. Market analyses.
OCP	Ben Guerir	Supplier phosphate rock	Fertilizer products and knowledge development, R&D.
UM6P		Mohammed VI Polytechnic University	Adaptive strategies, (market) solutions and alternative crops to mitigate salinity effect

Development impact

The demos will lead to applied knowledge transfer on how to engage in and undertake agricultural activities in a sustainable way in marginal and salt-affected areas. The development impact will be manifold:

1. SME farmers will be able to capture, store and make better use of the existing water resources and increase the crop yield and their livelihoods.
2. Larger investors will be able to manage their crops and water resources in a more sustainable way, increasing the return on their investments in the long run.

3. Companies that aim to produce on large tracts of land will be exposed to effective land and water resources management technologies that will make their production more sustainable and will lead to better results following soil improvement and lower costs of water systems.
4. Introduction of climate resilient farming practices will have a beneficial and restorative impact to the ecosystem, as soil cover is increased. Improved soil health and the planting of trees (e.g. windbreakers) will lead to carbon sequestration, decreased wind erosion of topsoil, improved water retention and groundwater levels and – when more and more trees/ shrubs, hedges are planted – to a positive change in the micro-climate.
5. Increased awareness on how to manage limited water resources and how to adapt agricultural practices to the changing climatic context is relevant to large parts of Morocco and is likely to receive increasing support by government organisations and NGO's, also due to being an important food supplier to EU markets.

Target groups

1. SME Farmers and farmer groups in Errachidia and Agadir:

- We aim to train 1,000 farmers in phase 2 and 3 of the project (on average 10 per week), via a training of trainers programme.
- We expect that 30% of these 1,000 farmers will implement one or more salinization, soil and water management solutions from one of the four groups introduced under Phase 1.
- The implementing 300 farmers will likely see their production per acre increase significantly (at least 50% higher income in the second year of implementation) due to better approaches, water use and availability and more appropriate crop selection

2. Large scale investors in agribusiness in oasis and the coastal region (50):

- We expect to be able to provide commercial services (project design and adjustment, implementation service and monitoring of results) to 10 large scale investors (>200 acres of land under cultivation)

Long-term impact

As we work with a local implementation partners who are willing to invest with us in setting up these demos, and who are also able to provide continued extension services and technical advice pertaining to the implementation of our solutions, we see the demos as firmly rooted. Given the increased demand for water resources in the two regions, we are convinced that the demand for our solutions in the agricultural sector will increase as well.

Risk analysis

Willingness to pay for new soil and water management solutions is often a challenge. We seek to overcome the risk of insufficient demand by approaching our target groups in ways that they can relate to most: practical demonstrations and training by local experts that are trained by us.

Another risk is an incomplete implementation of our solutions by farmers and commercial farming and forestry operations. We will mitigate this risk by having an extension service in place. The costs of the extension services will be partly covered by our local partner, who has a vested interest in expanding their network of outgrower farmers to increase their production. Also, other partners listed have shown interest in providing farmers with solutions that can make them more resilient.

Appendix 1. Overview of people involved in the study visit

Name	Function	Organisation	gender
Thami Alami Imane	Research Director	INRA-Rabat	F
Tarik Benabdelouaheb	Head of Soil and Environment	INRA-Rabat	M
Abdelali Mouaaid	Monitoring and evaluation	INRA-Rabat	M
Douaile Ahmed	Researcher	INRA-Rabat	M
Zouahri Abdelmajid	Researcher	INRA-Rabat	M
Lalaoui Rachidi Youssef	Researcher	INRA-Marrakech	M
Jamal Halloum	Researcher	INRA-Agadir	M
Essarou Achi	Researcher	INRA	M
Meziani Reda	Chef du Centre	INRA-Errachidia	M
Redouane Choukr_Allah	Senior Professor	UM6P	M
Aziz Soulaimani	AITTC laboratory Head	AITTC, UM6P	M
Mariam Moussafir	Researcher	AITTC, UM6P	F
Nawal TAAIME	PhD student	AITTC, UM6P	F
Younes Jnaoui	Experimental Farm Head	UM6P	M
Abba Ismail	Researcher	ABH-GZR	F
Hartid Fatima Eggehna	Researcher	ABH-GZR	F
Ait Mbirik Abdelaziz	DPA Director	DPA	M
Alaoui Maoujibi Abdel Mohaimin	Agronomist	DPA Rehamna	M
Daoud Fanissi	Chef du SPA	ORMVA	M
Mohammed Bachar	Chef de Departement	ANDZOA	M
Meziani Rech	Chef du Centre	ANDZOA	M
Noutfia Zahier		ANDZOA	F
Fadelt Mohamed		ANDZOA	M
Tayi Meriem		ANDZOA-DDZO	M
Victor Langenberg	Water expert	Acacia water	M
Arjen De Vos	Saline agriculture expert	The Salt Doctors	M
Nick Schelling	Adviser	Dutch Embassy	M
Mohamed Amine Moustanjidi	Cooperation Program Officer	Dutch Embassy	M

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This is a publication of

Netherlands Enterprise Agency
Prinses Beatrixlaan 2
PO Box 93144 | 2509 AC The Hague
T +31 (0) 88 042 42 42
Contact
www.rvo.nl

This publication was commissioned by the ministry of Foreign Affairs.
© Netherlands Enterprise Agency | January 2024

Publication number: RVO-024-2024/RP-INT

NL Enterprise Agency is a department of the Dutch ministry of Economic Affairs and Climate Policy that implements government policy for Agricultural, sustainability, innovation, and international business and cooperation. NL Enterprise Agency is the contact point for businesses, educational institutions and government bodies for information and advice, financing, networking and regulatory matters.

Netherlands Enterprise Agency is part of the ministry of Economic Affairs and Climate Policy.