SOIL SALINITY MANAGEMENT PLAN

Soil is one of the most vital components of our environment. Without the many benefits that soils provide, human existence would be extremely difficult. As such, soil is a precious resource that needs protecting from the many natural and human activities that degrade it.

And climates with low precipitation and high evaporation, such as experienced here in the UAE, highlight the need to identify the characteristics of soils and develop land management plans to protect as well as optimise the economical use of those soils.

Worldwide, every day some 2,000 ha of farm soil is lost due to salt-induced degradation. Soil salinity is the most significant form of soil degradation in Abu Dhabi Emirate, particularly on agricultural land. More than 80% of irrigated land in Abu Dhabi Emirate is affected negatively by salinity to various degrees, leading to reduced soil quality and crop production.

The Environment Agency – Abu Dhabi (EAD), in its Strategic Plan (2016-2020), made land and soil resources a strategic priority to ensure sustainable and integrated approaches to their protection. The strategic objectives of EAD aim at strengthening the policy and planning framework around soil quality, effectively influencing key stakeholder decisions, improving and enforcing the regulatory framework for soil quality, and ensuring land degradation management and restoration. In addition, EAD aims to ensure comprehensive understanding, knowledge and awareness building about soil quality in Abu Dhabi Emirate.

Over the past three years, EAD conducted the Soil Salinity Inventory Project, surveying soil salinity in 4,000 farms. EAD also implemented a monitoring programme for salinity changes in 100 farms across the Emirate of Abu Dhabi. Data from this project is included within EAD’s soil database providing decision-makers with up-to-date, accurate data on soil quality.

The primary outcome of this survey was the development of soil salinity maps, and an assessment of soil salinity management in the agricultural areas of Abu Dhabi Emirate. The evaluation showed that some of the farm area in Abu Dhabi region, Al Ain region, and Al Dhafra region had poorly managed salinity and which, if left unchecked, might significantly impact agricultural land sustainability. Therefore, and based on local Law Number 5 of 2016 on regulating the use of ground water in the emirate, EAD developed a Soil Salinity Management Plan to assist with managing and reclaiming salt-affected farms through its partner stakeholders to avoid further abandonment of agricultural farms.

The Soil Salinity Management Plan provides recommendations for each of the 16 Irrigation Districts in the Emirate of Abu Dhabi. Together with maps of soil suitability and groundwater quality data, the Soil Salinity Management Plan will enable us to optimise the use of available water resources and reduce the spread of agricultural land degradation due to soil salinity.

H.E. DR. SHEIKHA SALEM AL DHAIHERI
Secretary General of Environment Agency - Abu Dhabi
The Soil Salinity Management Plan was developed by a multidisciplinary team comprising experts from EAD and local governmental stakeholders. The strategic direction, progress and high-level review process was overseen by the Technical Committee, with implementation supervised on a day-to-day basis by the Environment Agency – Abu Dhabi.
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Al Khazma
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Sweihan
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OUTLOOK AND RECOMMENDATIONS
This Soil Management Plan was developed to put the dynamics of farm soil salinity into perspective, specifically considering the deterioration of irrigation water quality. It aims to develop a nationwide model for the optimization of available water and soil resources, to provide farmers with a clear perspective, and to reinforce the role of farmers as suppliers of healthy local agricultural goods.

The monitoring programme conducted by EAD helps establish a baseline for soil behaviour throughout the seasons in order to identify key performance indicators for the implementation of a future management plan for agricultural soil.

Also, the development of a local comprehensive agricultural soil management plan in collaboration with ADAFSA should consider other aspects other than soil such as good agricultural and irrigation practices, pressure-optimized irrigation systems, optimal timing and irrigation quantities, appropriate leaching fractions, and the introduction and testing of salinity adapted crops.

The Soil Management Plan (SMP) presented in this document is divided into three subsections.

**OVERVIEW**

This Soil Management Plan was developed to put the dynamics of farm soil salinity into perspective, specifically considering the deterioration of irrigation water quality. It aims to develop a nationwide model for the optimization of available water and soil resources, to provide farmers with a clear perspective, and to reinforce the role of farmers as suppliers of healthy local agricultural goods.

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The Soil Management Plan (SMP) presented in this document is divided into three subsections.

**SECTION I**

General principles for the best use of groundwater resources, and the maintenance and improvement of soil resources. This section includes a soil suitability classification for the Emirate of Abu Dhabi and identifies potential priority areas for agricultural activities.

**SECTION II**

Recommended actions are listed in separate tables for each of the 16 irrigation districts. A description is given of the existing conditions of irrigated soils and irrigation water, and specific recommendations are developed for each area (irrigation, crop selection, fertilization and other parameters). Properties and recommendations are tailored to be cross checked with the third section for the meaning and significance of their terms.

**SECTION III**

Terms, categories and classes of soil and irrigation water are explained as used in the characterization and recommendations produced for each individual irrigation district. Explanations and examples are also provided for crop water requirements and leaching requirements.
Comprehensive soil management goes beyond crop management recommendations to include integrated policy making and the consideration of soil, water resources, food security, and agricultural and general economic development, among others. For any nation to successfully and sustainably manage its natural resources, clear policies are essential.

On a national scale, farm soil resources (soil irrigation suitability) should match available water resources in both quality and quantity. The current soil survey on agricultural farms established a relevant information base that has been linked to, and complements, the EAD UAESIS System for non-agricultural areas.

As it stands, soils with restricted irrigation suitability (insufficient depth, imperfect drainage, high Gypsum or Calcium Carbonate content, topography, coarse texture) are being cultivated while other far more suitable soils are being overlooked. Figure 1 provides an overview of soil irrigation suitability in the Emirate of Abu Dhabi.

**SECTION I: GENERAL RECOMMENDATIONS FOR SOIL MANAGEMENT**

![FIGURE 1: Soil Irrigation Suitability in the Emirate of Abu Dhabi](image)
Alternatively, land with suitable characteristics is being rendered useless due to the deterioration of water quality as over-extraction leads the soil to face severe degradation. Figure 2 shows groundwater quality in terms of Total Dissolved Solids. A long-term policy should match good quality water resources to the best available soils (Figure 1, Figure 2) by providing incentives to abandon locations with highly saline water and/or soil resources with severe restrictions. Farm soil survey mapping and UAESIS data from the Soil Map of the Emirate of Abu Dhabi should be leveraged as much as possible to shape future regional agricultural policies.

**SUITABLE AGRICULTURAL AREAS CAN BE IDENTIFIED THROUGH THE GROUNDWATER WELL INVENTORY, THE FARM SOIL SALINITY MAP, AND THE UAESIS DATABASE.**

However, further water quality parameters and other factors such as infrastructure requirements, accessibility, etc. should be considered for this purpose. Dialogue with ADAFSA and other agricultural stakeholders will also help shape future regional agricultural policies.

- Conducting rural planning reviews to determine if good soil resources match good water resources and vice versa.
- Reviewing the suitability of locations with highly saline water and/or soil resources with severe restrictions.
- If practical, reviewing the possibility of relocating agricultural properties and businesses.
SOIL SALINITY MANAGEMENT PLAN

For example, well water should be used for salinity resistant crops while desalinated water should be restricted to high value vegetable crops. Treated Sewage Effluent (TSE) use should be actively expanded wherever possible and directed to forestry, ornamentals and fruit trees (date palms) that do not come into direct contact with human consumption.

- In urban and rural planning, additional sewage treatment plants should be made available in proximity to potential users.

• In urban and rural planning, additional sewage treatment plants should be made available in proximity to potential users.

FURTHER TO SUCH A POLICY, A STRATEGY TO DIRECT ABU DHABI’S THREE MAIN WATER RESOURCES (GROUNDWATER, DESALINATED WATER AND TREATED SEWAGE EFFLUENT/ TSE) SHOULD BE DEVELOPED TO ENSURE OPTIMAL USE.

Therefore, urban and rural planning should consider placing sewage collection and treatment infrastructures near potential users such as agricultural farms, landscape greenery, and protective forests.

The calculation of Crop Water Requirements based on climatic conditions should be compared with the actual use of irrigation water. When necessary, farmers should be made aware of any excessive use of water. Moreover, modern measuring instruments for measuring soil EC and humidity can be leveraged to optimize irrigation timing and conserve irrigation water. As for modern greenhouse technology, it can be used in combination with desalinated water (recycled evaporation water) and aquaponics, to help reach successful outcomes in a desert environment.

Any management recommendations issued to control salinity and alkalinity need to deal with the principal factors influencing salinity: precipitation, leaching, ascending capillary action of dissolved salts, irrigation management, heavy texture and impermeable layers.

APPROACHES:

- Introducing water metering and allocating water according to climatic Crop Water Requirements.
- Encouraging the use of modern measuring instrumentation (soil EC and humidity) to improve water allocation.
- Supporting modern greenhouse technology, recycled evaporation water, and aquaponics.
- Supporting salinity resistant plant research.
- Continuous Salinity Monitoring.

It should be noted that, due to the elevated cost and energy requirements of desalinated water application, priority should be given in this regard to crops with a high monetary value. Meanwhile, the use of TSE for date palms and ornamentals should be increased, provided there is no direct contact with the water.

• The use of TSE should be enabled close to principal farming areas through a distribution infrastructure.
• TSE should be used for forestry, palm trees, ornamentals, lawn production, sports grounds, etc.
• The use of energy-intensive desalinated water should be encouraged and limited to high-value crops.
• Well water use should be limited to salinity and alkalinity resistant crops.

Furthermore, scientific approaches should be enlisted to improve the reasonable use of soil and water resources: applying water in appropriate quantities according to crop water requirements and leaching needs.

POSSIBLE MANAGEMENT RECOMMENDATIONS INCLUDE:

Using the cooler and wetter seasons to leach out salts accumulated during the summer through dedicated leaching irrigation.

Using the best quality irrigation water available. Soil salinity conditions are linked to the quality of irrigation water. The use of desalinated water should be optimized by applying it to salinity sensitive crops with high market value.

Leveraging crust breaking of the soil surface and mulch covering to prevent capillary action, evaporation and salt deposits on the surface.

Avoiding irrigation beyond crop water requirements during the summer to avoid salt deposition, perched water tables and the capillary rise of salts.

Leveraging the recognized positive effect of organic fertilizers to attenuate the impact of salinity and alkalinity.

For non-saline sodic soils, applying gypsum amendments according to the registered pH.

For annual crops, adopting crop rotation within the farm: leaving a proportion of the surface fallow for some years to give the soil a chance to revert to lower salinity levels.
SECTION 2

SPECIFIC RECOMMENDATIONS FOR IRRIGATION DISTRICTS
SECTION 2: SPECIFIC RECOMMENDATIONS FOR IRRIGATION DISTRICTS

The below tables (tables 1 to 15) map out farm areas based on their unique combination of soil properties, soil salinity, and the availability of irrigation water, both in terms of quantity and quality. These areas are referred to as Irrigation Districts (Figure 3).

From these particular combinations common and specific restrictions and recommendations for each irrigation district with regard to soil, irrigation, and salinity management are presented.

Each table outlines existing conditions for soil and irrigation water in the relevant irrigation district. It further offers recommendations regarding irrigation, leaching (desalination), crop selection, fertilization, drainage control, alkalinity control, and melioration measure. These recommendations are provided for every major soil unit that makes up the irrigation district. As a rule, soil units covering less than 5% of the surface have been omitted but were still listed for the sake of comprehensiveness.

Section III (1.4) offers a detailed explanation of each existing condition and recommendation.
**SOIL SALINITY MANAGEMENT PLAN**

**TEXTURE ORIGIN**

- Loamy sand: Desalinated

**SALINITY**

- ECw 1,500 µS/cm, low

**SAR**

- 3, low

**AVAILABLE QUANTITY**

- Limited: 50-100 cm

**ROOTING DEPTH**

- Limited 50-100 cm

**GROUNDWATER PRESENCE**

- By leakage or over-irrigation

**FERTILITY**

- Moderate

**DRAINAGE**

- Limited by hardpan/lithic layers

**PERMEABILITY**

- Moderate

**GENERAL CHARACTERISTICS**

- Calico/gypsum layers, lithic conditions

**TABLE 1: Existing Conditions and Recommendations for Ajban Palace**

**IRRIGATION WATER EXISTING CONDITIONS**

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIGIN</td>
<td>Desalinated</td>
</tr>
<tr>
<td>SALINITY</td>
<td>ECw 1,500 µS/cm, low</td>
</tr>
<tr>
<td>SAR</td>
<td>3, low</td>
</tr>
<tr>
<td>AVAILABLE QUANTITY</td>
<td>Limited</td>
</tr>
<tr>
<td>CURRENT AVERAGE USE</td>
<td>M3/IRRIGATED HA</td>
</tr>
</tbody>
</table>

| FIGURE 3: Main Irrigation Districts in the Emirate of Abu Dhabi |
Recommendations for Ajban Palace

**MAP UNITS**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>TPC03</th>
<th>TTP09</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td>Lithic Haplocalcids, Typic Haplocalcids, lithic Phase, Typic Petrocalcids consociation, shallow, deflation plain</td>
<td>Typic Torripsamments consociation, rolling plain and dunes</td>
</tr>
<tr>
<td><strong>SUITABILITY</strong></td>
<td>SUIT</td>
<td>RESTR 1</td>
</tr>
<tr>
<td><strong>SUITABILITY</strong></td>
<td>SI</td>
<td>5</td>
</tr>
</tbody>
</table>

**IRRIGATION**

- Avoid irrigation beyond crop water requirement all-year crops with drip irrigation no more than 32,000 m³/ha.
- Switch from flood irrigation to sprinkler or drip.

**LEACHING (DESALINATION)**

- Not needed only if ECe exceeds 2,000 µS/cm, equivalent to EC (1:1) 590 µS/cm (local factor: 3.38). Use winter time for leaching.

**CROP SELECTION**

- Shallow rooting crops, otherwise in respect to salinity, suitable for all crops.

**FERTILIZATION**

- Moderate level

**DRAINAGE CONTROL**

- Avoid irrigation beyond crop water requirement

**ALKALINITY CONTROL**

- Not needed

**MELIORATION MEASURE**

- None

**Total Farm Area**

- **TC03**: 1,464.6 ha (78%)
- **TTP09**: 256.9 ha (14%)
Al Khatim

SOIL EXISTING CONDITIONS

TEXTURE
Sandy

GENERAL CHARACTERISTICS
Calcic, gypsic layers

ROOTING DEPTH
>150 cm

SALINITY
ECw 16,000-40,000 µS/cm, strongly saline

GROUNDWATER PRESENCE
None

FERTILITY
Low to moderate

DRAINAGE
Well drained

PERMEABILITY
Good to excessive

IRRIGATION WATER EXISTING CONDITIONS

ORIGIN
Well water

SALINITY
ECw 18,000 µS/cm, very high

SAR
27, very high

AVAILABLE QUANTITY
Available

CURRENT AVERAGE USE M3/IRRIGATED HA
58,000, high

TABLE 2: Existing Conditions and Recommendations for Al Khatim

FIGURE 5: Soil Irrigation Suitability in Al Khatim Palace
Recommendations for Al Khatim

**FIGURE 6: Soil Classification in Al Khatim**

- **Map Units**
  - THC01
  - TTP08

<table>
<thead>
<tr>
<th>Map Units</th>
<th>THC01</th>
<th>TTP08</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Farm Area</strong></td>
<td>663.6 ha</td>
<td>1,592.8 ha</td>
</tr>
<tr>
<td><strong>Percentage</strong></td>
<td>24%</td>
<td>58%</td>
</tr>
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</table>

**MAP UNITS**

<table>
<thead>
<tr>
<th>THC01</th>
<th>TTP08</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td>Typic Haplocalcids - Typic Torripsamments association, almost level to gently undulating deflation plain</td>
</tr>
<tr>
<td><strong>SUITABILITY</strong></td>
<td>SUSTR 1</td>
</tr>
<tr>
<td><strong>RESTRICTIONS</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>IRRIGATION</strong></td>
<td>All-year crops with drip irrigation, no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
</tr>
<tr>
<td><strong>LEACHING (DESALINATION)</strong></td>
<td>Target salinity maximum 1.5 x of irrigation water salinity; apply leaching fraction 22% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.</td>
</tr>
<tr>
<td><strong>CROP SELECTION</strong></td>
<td>Moderately salinity resistant crops: Alfalfa, Vegetables</td>
</tr>
<tr>
<td><strong>FERTILIZATION</strong></td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
</tr>
<tr>
<td><strong>DRAINAGE CONTROL</strong></td>
<td>n/a.</td>
</tr>
<tr>
<td><strong>ALKALINITY CONTROL</strong></td>
<td>Gypsum soil amendments when using desalinated water</td>
</tr>
<tr>
<td><strong>MELIORATION MEASURE</strong></td>
<td>None</td>
</tr>
</tbody>
</table>
Al Nahda, Al Shamka South

**SOIL EXISTING CONDITIONS**
Al Nahda, Al Shamka South

- **TEXTURE**
  - Sand

- **GENERAL CHARACTERISTICS**
  - Calcic, gypsic layers

- **ROOTING DEPTH**
  - >150 cm

- **SALINITY**
  - ECw 3,300 µS/cm, low
  - ECe 2,000-8,000 µS/cm, low to moderate salinity

- **GROUNDWATER PRESENCE**
  - By leakage or over-irrigation

- **FERTILITY**
  - Low to moderate

- **DRAINAGE**
  - Well drained

- **PERMEABILITY**
  - Good to excessive

**IRRIGATION WATER EXISTING CONDITIONS**
Al Nahda, Al Shamka South

- **ORIGIN**
  - Desalinated

- **SALINITY**
  - ECw 3,300 µS/cm, low

- **SAR**
  - 8, medium

- **AVAILABLE QUANTITY**
  - Available

- **CURRENT AVERAGE USE M3/IRRIGATED HA**
  - 27,000 (estimated), insufficient

**TABLE 3: Existing Conditions and Recommendations for Al Nahda, Al Shamka South**

**FIGURE 7: Soil Irrigation Suitability in Al Khatim**

Soil irrigation suitability in Al Khatim:
- S1: Suitable with few restrictions
- S2: Suitable with some restrictions
- S3: Suitable with many restrictions
- NZ: Presently unsuitable, may be suitable with high rehabilitative effort
- Not Classifiable
- Farm Areas

Types of soil suitability:
- Sand
- Loam
- Clay
- Silt
- Loess
- Peat
- Gleysol
- Salt flats
- Artificial soil

**TABLE 2: General Soil Characteristics**

<table>
<thead>
<tr>
<th>Text Type</th>
<th>Subdivision</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Origin</td>
<td>Desalinated</td>
<td>Sand, loam, clay, silt, loess, peat, gleysol, salt flats, artificial soil</td>
</tr>
<tr>
<td>Salinity</td>
<td>ECw 3,300 µS/cm, low</td>
<td>ECe 2,000-8,000 µS/cm, low to moderate salinity</td>
</tr>
<tr>
<td>Rooting Depth</td>
<td>&gt;150 cm</td>
<td></td>
</tr>
<tr>
<td>Water Presence</td>
<td>By leakage or over-irrigation</td>
<td></td>
</tr>
<tr>
<td>Fertility</td>
<td>Low to moderate</td>
<td></td>
</tr>
<tr>
<td>Drainage</td>
<td>Well drained</td>
<td></td>
</tr>
<tr>
<td>Permeability</td>
<td>Good to excessive</td>
<td></td>
</tr>
</tbody>
</table>
SOIL SALINITY MANAGEMENT PLAN

FIGURE 8: Soil Classification in Al Nahda, Al Shamka South

Recommendations for Al Nahda, Al Shamka South

Map Units

<table>
<thead>
<tr>
<th>Map Units</th>
<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>221.7 ha</td>
<td>351.3 ha</td>
<td>124.5 ha</td>
</tr>
<tr>
<td>31%</td>
<td>50%</td>
<td>18%</td>
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</table>

MAP UNITS

<table>
<thead>
<tr>
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<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-filled</td>
<td>Typic Hapludolls - Typic Torripsamments association, almost level to gently undulating deflation plan</td>
<td>Typic Hapludolls - Typic Torripsamments association, almost level to gently undulating deflation plan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SUITABILITY</td>
<td>RESTRICTED 1</td>
<td>RESTRICTED 2</td>
</tr>
<tr>
<td></td>
<td>RESTRICTED 1</td>
<td>RESTRICTED 2</td>
<td>RESTRICTED 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IRRIGATION</th>
<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-classified</td>
<td>All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
<td>All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEACHING (DESALINATION)</th>
<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not needed, only if ECe exceeds 2,000 µS/cm, equivalent to EC (1:1) 580 µS/cm (local factor: 3.46). Use winter season for leaching</td>
<td>Not needed, only if ECe exceeds 2,000 µS/cm, equivalent to EC (1:1) 580 µS/cm (local factor: 3.46). Use winter season for leaching</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CROP SELECTION</th>
<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>In respect to salinity suitable for all crops</td>
<td>Shallow rooting crops, otherwise in respect to salinity, suitable for all crops</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FERTILIZATION</th>
<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate level</td>
<td>Moderate level</td>
<td>Moderate level</td>
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<table>
<thead>
<tr>
<th>DRAINAGE CONTROL</th>
<th>MISC 1</th>
<th>THC01</th>
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</tr>
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<tbody>
<tr>
<td>n.a.</td>
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<table>
<thead>
<tr>
<th>ALKALINITY CONTROL</th>
<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not needed</td>
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<table>
<thead>
<tr>
<th>MELIORATION MEASURE</th>
<th>MISC 1</th>
<th>THC01</th>
<th>TPC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
Al Rahba, Shahama

SOIL EXISTING CONDITIONS

TEXTURE
Loamy sand

GENERAL CHARACTERISTICS
Calcareous/gypsic layers, lithic conditions

ROOTING DEPTH
50-100 cm

SALINITY
ECe 200-4000 µS/cm, slightly saline

GROUNDWATER PRESENCE
By leakage or over-irrigation

FERTILITY
Moderate

DRAINAGE
Limited by hardpan/lithic layers

PERMEABILITY
Moderate

IRRIGATION WATER EXISTING CONDITIONS

ORIGIN
Desalinated

SALINITY
ECw 200 µS/cm, low

SAR
12, medium

AVAILABLE QUANTITY
Limited

CURRENT AVERAGE USE
M3/IRRIGATED HA
26,000 (estimated), insufficient

TABLE 4: Existing Conditions and Recommendations for Al Rahba, Shahama

FIGURE 9: Soil Irrigation Suitability in Al Nahda, Al Shamka South

Soil Irrigation Suitability (Al Nahda, Al Shamka South)

- S1: Suitable with few restrictions
- S2: Suitable with some restrictions
- S3: Suitable with many restrictions
- N1: Potentially unsuitable, may be suitable with high mechanization effort
- N2: Permanently unsuitable
- N3: Not classified

Kilometers

FIGURE 9: Soil Irrigation Suitability in Al Nahda, Al Shamka South
SOIL SALINITY MANAGEMENT PLAN

FIGURE 10: Soil Classification in Al Rahba, Shahama

Recommendations for Al Rahba, Shahama

<table>
<thead>
<tr>
<th>MAP UNITS</th>
<th>TPC03</th>
</tr>
</thead>
</table>
| DESCRIPTION | Typic Haplocalcids, lithic phase, Typic Petrocalcids<br> | <br>  
| SUITABILITY | RESTRICTION 1<br>RESTRICTION 2<br>RESTRICTION 3<br> | <br>  
| IRRIGATION | Avoid irrigation beyond crop water requirement. All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip.<br> | <br>  
| LEACHING (DESALINATION) | Not needed, only if EC exceed 2,000 pS/cm, equivalent to EC (1:1) 560 pS/cm (local factor: 3.54). Use winter season for leaching.<br> | <br>  
| CROP SELECTION | Shallow rooting depths, otherwise in respect to salinity suitable for all crops. Avoid citrus, nuts, avocado and other alkalinity susceptible crops.<br> | <br>  
| FERTILIZATION | Moderate level<br> | <br>  
| DRAINAGE CONTROL | Avoid irrigation beyond crop water requirement.<br> | <br>  
| ALKALINITY CONTROL | Not needed, avoid susceptible crops.<br> | <br>  
| MELODIFICATION MEASURE | None<br> | <br>  

Map Units TPC03

Total Farm Area

3,958.8 ha

2,144.0 ha

54%
SOIL SALINITY MANAGEMENT PLAN

SOIL SALINITY MANAGEMENT PLAN

Avoid irrigation beyond crop water requirement; all-year crops with drip irrigation no more than 32,000 m3/ha.
Switch from flood irrigation to sprinkler or drip.

Typic Torripsamments - Typic Aquisols - Typic Haplsalids - Gypsic Haplsalids complex, gently undulating to rolling plains

Avoid irrigation beyond crop water requirement; all-year crops with drip irrigation no more than 32,000 m3/ha.
Switch from flood irrigation to sprinkler or drip.

Typic Torripsamments consociation, rolling plain and dunes

Not needed, only if ECe exceeds 2,000 µS/cm, equivalent to EC (1: 1) 560 µS/cm (local factor: 3.54). Use winter time for leaching.

In respect to salinity suitable for all crops.
Avoid citrus, nuts, avocado and other salinity susceptible crops.

Not needed, avoid susceptible crops

FIGURE 11: Soil Irrigation Suitability in Al Rahba, Shahama
### TABLE 5: Existing Conditions and Recommendations for Al Ain Urban, Al Jawf

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Origin</th>
<th>Salinity</th>
<th>SAR</th>
<th>Available Quantity</th>
<th>Current Average Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loamy sand</td>
<td>Well water, falaj</td>
<td>ECw 5,000 µS/cm, medium</td>
<td>7, low</td>
<td>Available</td>
<td>M3/IRRIGATED HA 28,000, insufficient</td>
</tr>
</tbody>
</table>

- **Texture**: Loamy sand
- **Origin**: Well water, falaj
- **Salinity**: ECw 5,000 µS/cm, medium
- **SAR**: 7, low
- **Available Quantity**: Available
- **Current Average Use**: M3/IRRIGATED HA 28,000, insufficient
SOIL SALINITY MANAGEMENT PLAN

Recommendations for Al Ain Urban, Al Jawf

**FIGURE 12:** Soil Classification in Al Ain Urban, Al Jawf

**Total Farm Area**: 3,871.4 ha

**Map Units**

**THC03**
- **Total Farm Area**: 594.4 ha (15%)
- **Suitability**: THC03
- **Description**: Typic Haplocalcids, Typic Calciqerts complex, deflation plains and low dunes
- **Irrigation**: All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip.
- **Leaching (Desalination)**: Target salinity maximum 1.5x of irrigation water salinity, apply leaching 31% above the crop water requirements (drip irrigation). No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.
- **Crop Selection**: Moderately salinity resistant crops: alfalfa, vegetables
- **Fertilization**: High level to achieve optimum yields
- **Drainage Control**: Avoid irrigation beyond crop water requirement
- **Alkalinity Control**: Not needed; avoid susceptible crops
- **Melioration Measure**: None

**THC04**
- **Total Farm Area**: 811.1 ha (21%)
- **Suitability**: THC04
- **Description**: Typic Haplocarbids, Typic Haplocambids, alluvial deposits
- **Irrigation**: All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip.
- **Leaching (Desalination)**: Target salinity maximum 1.5x of irrigation water salinity, apply leaching 31% above the crop water requirements (drip irrigation). No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.
- **Crop Selection**: Moderately salinity resistant crops: alfalfa, vegetables
- **Fertilization**: Low but frequent doses
- **Drainage Control**: Avoid irrigation beyond crop water requirement
- **Alkalinity Control**: Not needed; avoid susceptible crops
- **Melioration Measure**: Ground levelling
All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip. Target salinity maximum 1.5x of irrigation water salinity, apply leaching 31% above the crop water requirements (drip irrigation). No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.

Moderately salinity resistant crops: alfalfa, vegetables

Low but frequent doses

None

Not needed, avoid susceptible crops

Ground levelling

Ground levelling
### SOIL EXISTING CONDITIONS - Ajban East

**Texture**
- Loamy sand

**General Characteristics**
- Petrogypsic, petrocalcic layers

**Rooting Depth**
- 80 - 120 cm

**Salinity**
- ECw 15,500 µS/cm, high

**Groundwater Presence**
- By leakage or over-irrigation

**Fertility**
- Moderate

**Drainage**
- Limited by hardpan

**Permeability**
- Moderate

### Irrigation Water Existing Conditions - Ajban East

**Origin**
- Well water

**Salinity**
- ECw 15,500 µS/cm, high

**SAR**
- 22, very high

**Available Quantity**
- Available

**Current Average Use**
- M3/Irrigated HA
  - 71,000, excessive

Table 6: Existing Conditions and Recommendations for Ajban East
## Recommendations for Ajban East

### Map Units

<table>
<thead>
<tr>
<th>MAP UNITS</th>
<th>EHG01</th>
<th>THC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION</td>
<td>Leptic Haplogypsids - Typic Torripsamments - Typic Petrogypsids complex, level to gently undulating inland plains</td>
<td>Typic Haplocalcids - Typic Calchrysids complex, deflation plains and low dunes</td>
</tr>
<tr>
<td>SUITABILITY</td>
<td>REST 1</td>
<td>REST 2</td>
</tr>
<tr>
<td>IRRIGATION</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip irrigation.</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip irrigation.</td>
</tr>
<tr>
<td>LEACHING (DESALINATION)</td>
<td>Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 19% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.</td>
<td>Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 19% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.</td>
</tr>
<tr>
<td>CROP SELECTION</td>
<td>Moderately salinity resistant crops: alfalfa, vegetables</td>
<td>Moderately salinity resistant crops: alfalfa, vegetables</td>
</tr>
<tr>
<td>FERTILIZATION</td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
</tr>
<tr>
<td>DRAINAGE CONTROL</td>
<td>Avoid irrigation beyond crop water requirement</td>
<td>Avoid irrigation beyond crop water requirement</td>
</tr>
<tr>
<td>ALKALINITY CONTROL</td>
<td>gypsum soil amendments when using desalinated water</td>
<td>gypsum soil amendments when using desalinated water</td>
</tr>
<tr>
<td>MELIORATION MEASURE</td>
<td>Desalination plant</td>
<td>Desalination plant</td>
</tr>
</tbody>
</table>

### FIGURE 14: Soil Classification in Ajban East

![Soil Classification in Ajban East](image)

**SOIL SALINITY MANAGEMENT PLAN**

**Total Farm Area**

<table>
<thead>
<tr>
<th>Map Units</th>
<th>EHG01</th>
<th>THC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>3,388.0 ha</td>
<td>506.9 ha</td>
</tr>
<tr>
<td>%</td>
<td>11%</td>
<td>15%</td>
</tr>
</tbody>
</table>

**Map Units**

<table>
<thead>
<tr>
<th>MAP UNITS</th>
<th>EHG01</th>
<th>THC03</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION</td>
<td>Leptic Haplogypsids - Typic Torripsamments - Typic Petrogypsids complex, level to gently undulating inland plains</td>
<td>Typic Haplocalcids - Typic Calchrysids complex, deflation plains and low dunes</td>
</tr>
<tr>
<td>SUITABILITY</td>
<td>REST 1</td>
<td>REST 2</td>
</tr>
<tr>
<td>IRRIGATION</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip irrigation.</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip irrigation.</td>
</tr>
<tr>
<td>LEACHING (DESALINATION)</td>
<td>Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 19% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.</td>
<td>Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 19% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.</td>
</tr>
<tr>
<td>CROP SELECTION</td>
<td>Moderately salinity resistant crops: alfalfa, vegetables</td>
<td>Moderately salinity resistant crops: alfalfa, vegetables</td>
</tr>
<tr>
<td>FERTILIZATION</td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
</tr>
<tr>
<td>DRAINAGE CONTROL</td>
<td>Avoid irrigation beyond crop water requirement</td>
<td>Avoid irrigation beyond crop water requirement</td>
</tr>
<tr>
<td>ALKALINITY CONTROL</td>
<td>Gypsum soil amendments when using desalinated water</td>
<td>Gypsum soil amendments when using desalinated water</td>
</tr>
<tr>
<td>MELIORATION MEASURE</td>
<td>Desalination plant</td>
<td>Desalination plant</td>
</tr>
</tbody>
</table>
## Soil Salinity Management Plan

### Map Units

<table>
<thead>
<tr>
<th>Map Units</th>
<th>TPG04</th>
<th>TTP11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>1,990.3 ha</td>
<td>260.8 ha</td>
</tr>
</tbody>
</table>

### Suitability

- **TPG04**
  - Type: Petrogypsids - Leptic Haplogypsids - Typic Torripsamments complex, almost level to gently undulating
  - Targets: All-year crops with drip irrigation no more than 36,000 m$^3$/ha. Switch from flood irrigation to sprinkler or drip irrigation.
  - Leaching: Target salinity maximum 1.5 x of irrigation water salinity; apply leaching fraction 19% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.
  - CROP SELECTION: Only shallow rooting and extremely salt and alkalinity resistant crops, Rhodes grass, Alfalfa
  - FERTILIZATION: Moderate level, apply organic fertilizer for binding salinity
  - DRAINAGE CONTROL: Mid irrigation beyond crop water requirement
  - ALKALINITY CONTROL: Gypsum soil amendments when using desalinated water
  - MEILORATION MEASURE: Breaking of hardpan, desalination plant

- **TTP11**
  - Type: Torripsamments consociation, low dunes and sand plains
  - Targets: All-year crops with drip irrigation no more than 36,000 m$^3$/ha. Switch from flood irrigation to sprinkler or drip irrigation.
  - Leaching: Target salinity maximum 1.5 x of irrigation water salinity; apply leaching fraction 19% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.
  - CROP SELECTION: Salinity resistant crops: alfalfa, vegetables
  - FERTILIZATION: Moderate level, apply organic fertilizer for binding salinity

### Soil Irrigation Suitability Map

- **S1**: Suitable with few restrictions
- **S2**: Suitable with some restrictions
- **S3**: Suitable with many restrictions
- **NL**: Premarily unsuitable, may be suitable with high reclamation effort
- **NZ**: Permanently unsuitable

**FIGURE 15: Soil Classification in Ajabn East**
SOIL SALTITIVITY MANAGEMENT PLAN

Al Araad, Abu Krayyah, Al Dhahra

**SOIL EXISTING CONDITIONS**

- **TEXTURE**
  - Sand

- **GENERAL CHARACTERISTICS**
  - Levelled dunes

- **ROOTING DEPTH**
  - >150 cm

- **SALINITY**
  - ECe 8,000-40,000 µS/cm, medium to strongly saline

- **GROUNDWATER PRESENCE**
  - Absent

- **FERTILITY**
  - Low

- **DRAINAGE**
  - Excessive

- **PERMEABILITY**
  - Very good

**IRRIGATION WATER EXISTING CONDITIONS**

- **ORIGIN**
  - Well water

- **SALINITY**
  - ECw 13,000 µS/cm, high

- **SAR**
  - 18, high

- **AVAILABLE QUANTITY**
  - Available

- **CURRENT AVERAGE USE M3/IRRIGATED HA**
  - 33,000, slightly insufficient

**TABLE 7**: Existing Conditions and Recommendations for Al Araad, Abu Krayyah, Al Dhahra
### Recommendations for Al Araad, Abu Krayyah, Al Dhahra

**Total Farm Area:** 10,377.9 ha

- **TTP15:** 1,093 ha (11%)
- **TTP16:** 8,076.2 ha (78%)

<table>
<thead>
<tr>
<th>MAP UNITS</th>
<th>TTP15</th>
<th>TTP16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td>Typic Torripsamments consociation, rolling to steep barchanoid dunes</td>
<td>Typic Torripsamments consociation, rolling to steep barchanoid dunes</td>
</tr>
<tr>
<td><strong>SUITABILITY</strong></td>
<td>S3</td>
<td>RESTR 1</td>
</tr>
<tr>
<td><strong>RESTR 2</strong></td>
<td></td>
<td>RESTR 3</td>
</tr>
<tr>
<td><strong>LEACHING</strong></td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
</tr>
<tr>
<td>(DESALINATION)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IRRIGATION</strong></td>
<td>Irrigation not above 36,000 m3/h for all year crops with drip irrigation. Switch from flood irrigation to sprinkler or drip</td>
<td>Irrigation not above 36,000 m3/h for all year crops with drip irrigation. Switch from flood irrigation to sprinkler or drip</td>
</tr>
<tr>
<td><strong>CROP SELECTION</strong></td>
<td>Only extremely salt and alkalinity resistant crops: Date Palm, Rhodes grass, Alfalfa</td>
<td>Only extremely salt and alkalinity resistant crops: Date Palm, Rhodes grass, Alfalfa</td>
</tr>
<tr>
<td><strong>FERTILIZATION</strong></td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
</tr>
<tr>
<td><strong>DRAINAGE</strong></td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td><strong>CONTROL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ALKALINITY</strong></td>
<td>Gypsum soil amendments when using desalinated water</td>
<td>Gypsum soil amendments when using desalinated water</td>
</tr>
<tr>
<td><strong>CONTROL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MELIORATION</strong></td>
<td>Compost/manure, desalination plant</td>
<td>Compost/manure, desalination plant</td>
</tr>
</tbody>
</table>

*FIGURE 16: Soil Classification in Al Araad, Abu Krayyah, Al Dhahra*
**SOIL SALINITY MANAGEMENT PLAN**

**Al Hayer, Nahel town, Al Shwaib, Al Faqa**

**TABLE 8: Existing Conditions and Recommendations for Al Hayer, Nahel town, Al Shwaib, Al Faqa**

**SOIL EXISTING CONDITIONS**

- **Texture**: Sand
- **General Characteristics**: Levelled dunes
- **Rooting Depth**: >150 cm
- **Salinity**: ECw 4,000 µS/cm, low to medium
- **Groundwater Presence**: Absent
- **Fertility**: Low
- **Drainage**: Excessive
- **Permeability**: Very good
- **Origin**: Well water
- **Salinity**: ECw 4,000 µS/cm, low to medium
- **SAR**: 7.0
- **Available Quantity**: Limited
- **Current Average Use M3/Irrigated HA**: 26,000, insufficient

**IRRIGATION WATER EXISTING CONDITIONS**

- **Origin**: Well water
- **Salinity**: ECw 4,000 µS/cm, low to medium
- **SAR**: 7.0
- **Available Quantity**: Limited
- **Current Average Use M3/Irrigated HA**: 26,000, insufficient
### Recommendations for Al Hayer, Nahel town, Al Shwaib, Al Faqa

#### Map Units

<table>
<thead>
<tr>
<th>Map Units</th>
<th>TTP08</th>
<th>TTP13</th>
<th>TTP14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>962.2 ha</td>
<td>599.2 ha</td>
<td>2,037.4 ha</td>
</tr>
<tr>
<td>Total Farm Area %</td>
<td>12%</td>
<td>7%</td>
<td>25%</td>
</tr>
</tbody>
</table>

#### MAP UNITS

<table>
<thead>
<tr>
<th>TTP08</th>
<th>TTP13</th>
<th>TTP14</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION</td>
<td>Triticale Tundra (low)</td>
<td>Triticale Tundra (low)</td>
</tr>
<tr>
<td>SUITABILITY</td>
<td>RESTRICTED</td>
<td>RESTRICTED</td>
</tr>
<tr>
<td>IRRIGATION</td>
<td>Due to lack of water apply to high value crops only. For drip irrigation of all year crops do not exceed 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip.</td>
<td>Due to lack of water apply to high value crops only. For drip irrigation of all year crops do not exceed 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip.</td>
</tr>
<tr>
<td>LEACHING (DESLALINATION)</td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
</tr>
<tr>
<td>CROP SELECTION</td>
<td>Salinity resistant crops: vegetables</td>
<td>Moderately salinity resistant crops: vegetables, tomato, cucumber</td>
</tr>
<tr>
<td>FERTILIZATION</td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
</tr>
<tr>
<td>DRAINAGE CONTROL</td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td>ALKALINITY CONTROL</td>
<td>Not needed, avoid susceptible crops</td>
<td>Not needed, avoid susceptible crops</td>
</tr>
<tr>
<td>MELIORATION MEASURE</td>
<td>Compost/manure, ground levelling</td>
<td>Compost/manure</td>
</tr>
</tbody>
</table>

---

**FIGURE 18:** Soil Classification in Al Hayer, Nahel town, Al Shwaib, Al Faqa
SOIL SALINITY MANAGEMENT PLAN

FIGURE 19: Soil Irrigation Suitability in Nahel Town, Al Hayer, Al Shwaib, Al Faqa

Map Units

<table>
<thead>
<tr>
<th></th>
<th>TTP15</th>
<th>TTP16</th>
<th>TTP17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>1,737.1 ha</td>
<td>1,047.0 ha</td>
<td>547.7 ha</td>
</tr>
<tr>
<td>21%</td>
<td>13%</td>
<td>7%</td>
<td></td>
</tr>
</tbody>
</table>

**MAP UNITS**

<table>
<thead>
<tr>
<th></th>
<th>TTP15</th>
<th>TTP16</th>
<th>TTP17</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td>Typic Torripsamments consociation, rolling to steep barchanoid dunes</td>
<td>Typic Torripsamments consociation, rolling rises and flats</td>
<td>Typic Torripsamments consociation, low to moderately high active dunes</td>
</tr>
<tr>
<td><strong>IRRIGATION</strong></td>
<td>Due to lack of water apply to high value crops only. For drip irrigation of all year crops do not exceed 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
<td>Due to lack of water apply to high value crops only. For drip irrigation of all year crops do not exceed 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
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</tr>
<tr>
<td><strong>LEACHING (DESALINATION)</strong></td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
</tr>
<tr>
<td><strong>CROP SELECTION</strong></td>
<td>Salinity resistant crops: vegetables</td>
<td>Salinity resistant crops: vegetables</td>
<td>Moderately salinity resistant crops: vegetables, tomato, cucumber</td>
</tr>
<tr>
<td><strong>FERTILIZATION</strong></td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
</tr>
<tr>
<td><strong>DRAINAGE CONTROL</strong></td>
<td>Not needed</td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td><strong>ALKALINITY CONTROL</strong></td>
<td>Not needed, avoid susceptible crops</td>
<td>Not needed, avoid susceptible crops</td>
<td>Not needed, avoid susceptible crops</td>
</tr>
<tr>
<td><strong>MELIORATION MEASURE</strong></td>
<td>Compost/manure, ground levelling</td>
<td>Compost/manure</td>
<td>Compost/manure, ground levelling</td>
</tr>
</tbody>
</table>

**MAP UNITS**

<table>
<thead>
<tr>
<th></th>
<th>TTP15</th>
<th>TTP16</th>
<th>TTP17</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td>Typic Torripsamments consociation, rolling to steep barchanoid dunes</td>
<td>Typic Torripsamments consociation, rolling rises and flats</td>
<td>Typic Torripsamments consociation, low to moderately high active dunes</td>
</tr>
<tr>
<td><strong>IRRIGATION</strong></td>
<td>Due to lack of water apply to high value crops only. For drip irrigation of all year crops do not exceed 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
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</tr>
<tr>
<td><strong>LEACHING (DESALINATION)</strong></td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
</tr>
<tr>
<td><strong>CROP SELECTION</strong></td>
<td>Salinity resistant crops: vegetables</td>
<td>Salinity resistant crops: vegetables</td>
<td>Moderately salinity resistant crops: vegetables, tomato, cucumber</td>
</tr>
<tr>
<td><strong>FERTILIZATION</strong></td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
<td>Low fertilizer quantities in frequent doses, organic fertilizer</td>
</tr>
<tr>
<td><strong>DRAINAGE CONTROL</strong></td>
<td>Not needed</td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td><strong>ALKALINITY CONTROL</strong></td>
<td>Not needed, avoid susceptible crops</td>
<td>Not needed, avoid susceptible crops</td>
<td>Not needed, avoid susceptible crops</td>
</tr>
<tr>
<td><strong>MELIORATION MEASURE</strong></td>
<td>Compost/manure, ground levelling</td>
<td>Compost/manure</td>
<td>Compost/manure, ground levelling</td>
</tr>
</tbody>
</table>
### Al Khazna

#### SOIL EXISTING CONDITIONS

- **TEXTURE**
  - Sand

- **GENERAL CHARACTERISTICS**
  - Calcic, gypsic layers

- **ROOTING DEPTH**
  - >150 cm

- **SALINITY**
  - ECw 13,000 µS/cm, moderate salinity

- **GROUNDWATER PRESENCE**
  - By leakage or over-irrigation

- **FERTILITY**
  - Low to moderate

- **DRAINAGE**
  - Well drained

- **PERMEABILITY**
  - Good to very good

#### IRRIGATION WATER EXISTING CONDITIONS

- **ORIGIN**
  - Well water

- **SALINITY**
  - ECw 13,000 µS/cm, moderate

- **SAR**
  - 24, very high

- **AVAILABLE QUANTITY**
  - Available

- **CURRENT AVERAGE USE M3/IRRIGATED HA**
  - 40,000, slightly high

### TABLE 9: Existing Conditions and Recommendations for Al Khazna
SOIL SALINITY MANAGEMENT PLAN

FIGURE 20: Soil Classification in Al Khazna

Total Farm Area 1,890.6 ha

<table>
<thead>
<tr>
<th>Map Units</th>
<th>THC01</th>
<th>TTP06</th>
<th>TTP13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>880.8 ha</td>
<td>350.5 ha</td>
<td>506.7 ha</td>
</tr>
<tr>
<td>THC01</td>
<td>47%</td>
<td></td>
<td>27%</td>
</tr>
<tr>
<td>TTP06</td>
<td></td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>TTP13</td>
<td></td>
<td></td>
<td>19%</td>
</tr>
</tbody>
</table>

Recommendations for Al Khazna

**MAP UNITS**

- **DESCRIPTION**
  - **Typic Haplocalcids - Typic Torripsamments association, almost level to gently undulating deflation plan**
  - **Typic Torripsamments consociation, rolling dunes**
  - **Typic Torripsamments consociation, low dunes and inland plains**

- **IRRIGATION**
  - Avoid irrigation beyond crop water requirement all-year crops with drip irrigation no more than 36,000 m³/ha.
  - Switch from flood irrigation to sprinkler or drip
  - All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip

- **LEACHING (DESALINATION)**
  - Apply in winter months. Target salinity maximum 1.5 x of irrigation water salinity, apply 37% above crop water requirements (drip irrigation).
  - No extra leaching needed for flood irrigation (high percolation losses)
  - Apply in winter months. Target salinity maximum 1.5 x of irrigation water salinity, apply 37% above crop water requirements (drip irrigation).
  - No extra leaching needed for flood irrigation (high percolation losses)

- **CROP SELECTION**
  - Moderately salinity resistant crops: vegetables, tomato, cucumber, avoid alkalinity susceptible nuts, avocado, citrus, beans
  - Moderately salinity resistant crops: vegetables, tomato, cucumber, avoid alkalinity susceptible nuts, avocado, citrus, beans
  - Moderately salinity resistant crops: vegetables, tomato, cucumber, avoid alkalinity susceptible nuts, avocado, citrus, beans

- **FERTILIZATION**
  - Moderate level, apply organic fertilizer for binding salinity
  - Moderate level, apply organic fertilizer for binding salinity
  - Apply in small but frequent doses

- **DRAINAGE CONTROL**
  - Avoid irrigation beyond crop water requirement
  - Gypsum soil amendments when using desalinated water
  - Gypsum soil amendments when using desalinated water

- **ALKALINITY CONTROL**
  - Compost/manure
  - Compost/manure
  - Compost/manure

- **MELIORATION MEASURE**
  - Compost/manure, ground leveling
  - Compost/manure
  - Compost/manure
Al Salamat, Al Saad

Soil Suitability Map

Figure 21: Soil Irrigation Suitability in Al Khazna

Table 10: Existing Conditions and Recommendations for Al Salamat, Al Saad

Soil Irrigation Suitability [Al Khazna]
- S1: suitable with few restrictions
- S2: suitable with some restrictions
- S3: suitable with many restrictions
- S4: not classified

Texture
Loamy sand

Origin
Well water

Salinity
ECw 7,500 µS/cm, moderate

SAR
12, medium

Available Quantity
Available

Current Average Use
M3/IRRIGATED HA
25,000, insufficient

General Characteristics
Calcic, gypsic layers

Rooting Depth
>150 cm

Salinity
ECe 4,000-8,000 µS/cm, moderate salinity

Groundwater Presence
By leakage or over-irrigation

Fertility
Moderate

Drainage
Well drained

Permeability
Good
SOIL SALINITY MANAGEMENT PLAN

Recommendations for Al Salamat, Al Saad

MAP UNITS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>TCG01</th>
<th>THC01</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUITABILITY</td>
<td>RESTRICTION 1</td>
<td>RESTRICTION 2</td>
</tr>
<tr>
<td>TYPIC CALSIGYPSIDS - TYPIC TOMPASSIEMENTS COMPLEX, ALMOST LEVEL TO GENTLY UNDULATING</td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
</tr>
<tr>
<td>IRRIGATION</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
</tr>
<tr>
<td>LEACHING (DESALINATION)</td>
<td>Moderate salinity resistant crops: alfalfa, vegetables</td>
<td>Moderate salinity resistant crops: alfalfa, vegetables</td>
</tr>
<tr>
<td>FERTILIZATION</td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
</tr>
<tr>
<td>DRAINAGE CONTROL</td>
<td>Avoid irrigation beyond crop water requirement</td>
<td>Avoid irrigation beyond crop water requirement</td>
</tr>
<tr>
<td>ALKALINITY CONTROL</td>
<td>Gypsum soil amendments when using desalinated water</td>
<td>Gypsum soil amendments when using desalinated water</td>
</tr>
<tr>
<td>MELIORATION MEASURE</td>
<td>Compost/manure</td>
<td>Compost/manure</td>
</tr>
</tbody>
</table>

FIGURE 22: Soil Classification in Al Salamat, Al Saad
SOIL SALINITY MANAGEMENT PLAN

MAP UNITS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>THC03</th>
<th>TTP13</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2 suit</td>
<td>Typic Haplic Alfs, Typic Calcisols complex, deflation plains and loess dunes</td>
<td>Typic Torriaptorsamments consociation, low dunes and inland plains</td>
</tr>
<tr>
<td>S3 suit</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip.</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip.</td>
</tr>
<tr>
<td>S3 restr 1</td>
<td>Not needed with regular irrigation</td>
<td>Not needed with regular irrigation</td>
</tr>
<tr>
<td>S3 restr 2</td>
<td>Moderately salinity resistant crops: vegetables, tomato, cucumber, avoid alkalinity susceptible nuts, avocado, citrus, beans</td>
<td>Moderately salinity resistant crops: vegetables, tomato, cucumber, avoid alkalinity susceptible nuts, avocado, citrus, beans</td>
</tr>
<tr>
<td>S3 restr 3</td>
<td>Compost/manure, ground levelling</td>
<td>Gypsum soil amendments when using desalinated water</td>
</tr>
</tbody>
</table>

FIGURE 23: Soil Irrigation Suitability in Al Salamat, Al Saad

- S3: Suitable with low restrictions
- S2: Suitable with some restrictions
- S1: Permanently unsuitable
- S0: Not classified

Map Units

<table>
<thead>
<tr>
<th>Total Farm Area</th>
<th>THC03</th>
<th>TTP13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,119.2 ha</td>
<td>37%</td>
<td>635.8 ha</td>
</tr>
</tbody>
</table>
Al Wagan, Al Qua’a

### SOIL EXISTING CONDITIONS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEXTURE</strong></td>
<td>Sand</td>
</tr>
<tr>
<td><strong>GENERAL CHARACTERISTICS</strong></td>
<td>Calcic, gypsic layers levelled dunes</td>
</tr>
<tr>
<td><strong>ROOTING DEPTH</strong></td>
<td>&gt;150 cm</td>
</tr>
<tr>
<td><strong>SALINITY</strong></td>
<td>ECw 9,000-16,000 µS/cm, medium saline</td>
</tr>
<tr>
<td><strong>GROUNDWATER PRESENCE</strong></td>
<td>Absent/ by leakage or over-irrigation</td>
</tr>
<tr>
<td><strong>FERTILITY</strong></td>
<td>Low to moderate</td>
</tr>
<tr>
<td><strong>DRAINAGE</strong></td>
<td>Excessive/well drained</td>
</tr>
<tr>
<td><strong>PERMEABILITY</strong></td>
<td>Good to very good</td>
</tr>
</tbody>
</table>

### IRRIGATION WATER EXISTING CONDITIONS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ORIGIN</strong></td>
<td>Well water</td>
</tr>
<tr>
<td><strong>SALINITY</strong></td>
<td>ECw 9,000 µS/cm, moderate</td>
</tr>
<tr>
<td><strong>SAR</strong></td>
<td>14, high</td>
</tr>
<tr>
<td><strong>AVAILABLE QUANTITY</strong></td>
<td>Available</td>
</tr>
<tr>
<td><strong>CURRENT AVERAGE USE</strong></td>
<td>M3/IRRIGATED HA 36,000, good</td>
</tr>
</tbody>
</table>

**TABLE 11**: Existing Conditions and Recommendations for Al Wagan, Al Qua’a

---

*Note: The image contains a photograph of a person using a device to measure soil salinity.*
SOIL SALINITY MANAGEMENT PLAN

FIGURE 24: Soil Classification in Al Wagan, Al Qua’a

Recommendations for Al Wagan, Al Qua’a

**Map Units**

<table>
<thead>
<tr>
<th>Map Units</th>
<th>EHG01</th>
<th>TPG07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>559.1 ha</td>
<td>493.9 ha</td>
</tr>
<tr>
<td>%</td>
<td>9%</td>
<td>8%</td>
</tr>
</tbody>
</table>

**MAP UNITS**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>EHG01</th>
<th>TPG07</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td>Leptic Hapludults - Typic Hapludults complex, level to gently undulating inland plains</td>
<td>Typic Petroludults - Petrogypsic Haplustalfs complex, almost level to gently undulating</td>
</tr>
<tr>
<td><strong>SUITABILITY</strong></td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td><strong>RESTRICTION 1</strong></td>
<td>RESTR 1</td>
<td>RESTR 1</td>
</tr>
<tr>
<td><strong>RESTRICTION 2</strong></td>
<td>RESTR 2</td>
<td>RESTR 2</td>
</tr>
<tr>
<td><strong>RESTRICTION 3</strong></td>
<td>RESTR 3</td>
<td>RESTR 3</td>
</tr>
</tbody>
</table>

**IRRIGATION**

- All-year crops with drip irrigation no more than 32,000 m$^3$/ha. Switch from flood irrigation to sprinkler or drip

**LEACHING (DESLATION)**

- Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 28% above the crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching

**CROP SELECTION**

- Moderately saline and alkalinity resistant crops: alfalfa, vegetables

**FERTILIZATION**

- Moderate level, apply organic fertilizer for binding salinity

**DRAINAGE CONTROL**

- Not needed

**ALKALINITY CONTROL**

- Not needed

**MELIORATION MEASURE**

- Compost/manure, breaking of hardpan

[Map and diagram of soil classification in Al Wagan, Al Qua’a]
SOIL SALINITY MANAGEMENT PLAN

**DESCRIPTION**

**IRRIGATION**
All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip

**LEACHING (DESALINATION)**
Target salinity maximum 1.5 x of irrigation water salinity. Apply leaching fraction 28% above the crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching

**CROP SELECTION**
Moderately salinity and alkalinity resistant crops: alfalfa, vegetables

**FERTILIZATION**
Apply in small but frequent doses

**DRAINAGE CONTROL**
Not needed

**ALKALINITY CONTROL**
Not needed

**MELIORATION MEASURE**
Compost/manure, ground levelling

---

**MAP UNITS**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>TTP15</th>
<th>TTP16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IRRIGATION</strong></td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
<td>All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
</tr>
<tr>
<td><strong>LEACHING (DESALINATION)</strong></td>
<td>Target salinity maximum 1.5 x of irrigation water salinity. Apply leaching fraction 28% above the crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching</td>
<td>Target salinity maximum 1.5 x of irrigation water salinity. Apply leaching fraction 28% above the crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching</td>
</tr>
<tr>
<td><strong>CROP SELECTION</strong></td>
<td>Moderately salinity and alkalinity resistant crops: alfalfa, vegetables</td>
<td>Moderately salinity and alkalinity resistant crops: alfalfa, vegetables</td>
</tr>
<tr>
<td><strong>FERTILIZATION</strong></td>
<td>Apply in small but frequent doses</td>
<td>Apply in small but frequent doses</td>
</tr>
<tr>
<td><strong>DRAINAGE CONTROL</strong></td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td><strong>ALKALINITY CONTROL</strong></td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td><strong>MELIORATION MEASURE</strong></td>
<td>Compost/manure, ground levelling</td>
<td>Compost/manure, ground levelling</td>
</tr>
</tbody>
</table>

**Total Farm Area**

- **TTP15**: 3,003.6 ha (50%)
- **TTP16**: 650.6 ha (11%)

**Map Units**

- **TTP15**
- **TTP16**

**Soil Irrigation Suitability in Al Wagan, Al Qua’a**

**FIGURE 25**
### Remah

<table>
<thead>
<tr>
<th>SOIL EXISTING CONDITIONS</th>
<th>Remah</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEXTURE</strong></td>
<td>Sand</td>
</tr>
<tr>
<td><strong>GENERAL CHARACTERISTICS</strong></td>
<td>Levelled dunes</td>
</tr>
<tr>
<td><strong>ROOTING DEPTH</strong></td>
<td>&gt;150 cm</td>
</tr>
<tr>
<td><strong>SALINITY</strong></td>
<td>ECw 7,700 µS/cm, moderate</td>
</tr>
<tr>
<td><strong>GROUNDWATER PRESENCE</strong></td>
<td>Absent</td>
</tr>
<tr>
<td><strong>FERTILITY</strong></td>
<td>Low</td>
</tr>
<tr>
<td><strong>DRAINAGE</strong></td>
<td>Excessive</td>
</tr>
<tr>
<td><strong>PERMEABILITY</strong></td>
<td>Very good</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IRRIGATION WATER EXISTING CONDITIONS</th>
<th>Remah</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ORIGIN</strong></td>
<td>Well water</td>
</tr>
<tr>
<td><strong>SALINITY</strong></td>
<td>ECw 7,700 µS/cm, moderate</td>
</tr>
<tr>
<td><strong>SAR</strong></td>
<td>1.4, high</td>
</tr>
<tr>
<td><strong>AVAILABLE QUANTITY</strong></td>
<td>Available</td>
</tr>
<tr>
<td><strong>CURRENT AVERAGE USE</strong></td>
<td>M3/IRRIGATED HA 32,000, slightly insufficient</td>
</tr>
</tbody>
</table>

**TABLE 12:** Existing Conditions and Recommendations for Remah
SOIL SALINITY MANAGEMENT PLAN

Recommendations for Remah

**Figure 26: Soil Classification in Remah**

<table>
<thead>
<tr>
<th>Map Units</th>
<th>TTP06</th>
<th>TTP08</th>
<th>TTP13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>8,507.6 ha</td>
<td>51.1.0 ha</td>
<td>3,950.4 ha</td>
</tr>
<tr>
<td></td>
<td>6%</td>
<td>46%</td>
<td>41%</td>
</tr>
</tbody>
</table>

**Map Units**

- **TTP06**: Typic Torripsamments, consociation, low to moderately high active dunes
- **TTP08**: Typic Torripsamments, consociation, low dunes and inland plains
- **TTP13**: Typic Torripsamments, consociation, low to moderately high active dunes

**Description**

- **SUITABILITY**: RESTRICTION 1
- **SUITABILITY**: RESTRICTION 2
- **SUITABILITY**: RESTRICTION 3

**Irrigation**

- All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip

**Leaching (Desalination)**

- Not needed with regular irrigation

**Crop Selection**

- In respect to salinity suitable for all crops, not suitable for alkalinity susceptible plants nuts, citrus, avocado, beans

**Fertilization**

- Low fertilizer quantities in frequent doses, organic fertilizer

**Drainage Control**

- Not needed

**Alkalinity Control**

- Gypsum soil amendments when using desalinated water, avoid susceptible crops

**Melioration Measure**

- Compost/manure, ground leveling
TABLE 13: Existing Conditions and Recommendations for Sweihan

Sweihan

SOIL EXISTING CONDITIONS

- **TEXTURE**
  - Loamy sand

- **GENERAL CHARACTERISTICS**
  - Petrogypsic, petrocalcic layers

- **ROOTING DEPTH**
  - 80 - 120 cm

- **SALINITY**
  - ECw 11,000 µS/cm, medium to high salinity

- **GROUNDWATER PRESENCE**
  - By leakage or over-irrigation

- **FERTILITY**
  - Moderate

- **DRAINAGE**
  - Limited by hardpan

- **PERMEABILITY**
  - Moderate

IRRIGATION WATER EXISTING CONDITIONS

- **ORIGIN**
  - Well water

- **SALINITY**
  - ECw 11,000 µS/cm, medium to high

- **SAR**
  - 24, very high

- **AVAILABLE QUANTITY**
  - Available

- **CURRENT AVERAGE USE**
  - 34,000, good

FIGURE 27: Soil Irrigation Suitability in Remah
Recommendations for Sweihan

**Map Units**

<table>
<thead>
<tr>
<th>Map Units</th>
<th>EHG01</th>
<th>THC03</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Farm Area</strong></td>
<td>1,175.1 ha</td>
<td>530.0 ha</td>
</tr>
</tbody>
</table>

**EHG01**

- **DESCRIPTION**: Leptic Haplogypsids - Typic Torripsamments - Typic Petrogypsids complex, level to gently undulating inland plains
- **SUITABILITY**: SUITABILITY RESTR 1
- **IRRIGATION**: All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip
- **LEACHING**: Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 14% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching
- **CROP SELECTION**: Only extremely salt and alkalinity resistant crops: Rhodes grass, Alfalfa, shallow rooting
- **FERTILIZATION**: Moderate level, apply organic fertilizer for binding salinity
- **DRAINAGE CONTROL**: Avoid irrigation beyond crop water requirement
- **ALKALINITY CONTROL**: Gypsum soil amendments when using desalinated water
- **MELIORATION MEASURE**: Desalination plant, compost/manure, breaking of hardpan

**THC03**

- **DESCRIPTION**: Leptic Haplogypsids - Typic Torripsamments - Typic Petrogypsids complex, level to gently undulating inland plains
- **SUITABILITY**: SUITABILITY RESTR 1
- **IRRIGATION**: All-year crops with drip irrigation no more than 36,000 m³/ha. Switch from flood irrigation to sprinkler or drip
- **LEACHING**: Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 14% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching
- **CROP SELECTION**: Only extremely salt and alkalinity resistant crops: Rhodes grass, Alfalfa, shallow rooting
- **FERTILIZATION**: Moderate level, apply organic fertilizer for binding salinity
- **DRAINAGE CONTROL**: Avoid irrigation beyond crop water requirement
- **ALKALINITY CONTROL**: Gypsum soil amendments when using desalinated water
- **MELIORATION MEASURE**: Desalination plant, compost/manure, breaking of hardpan

** FIGURE 28: Soil Classification in Sweihan **
## Soil Salinity Management Plan

**Map Units**

<table>
<thead>
<tr>
<th>Map Units</th>
<th>TTP06</th>
<th>TTP13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>173.5 ha</td>
<td>233.8 ha</td>
</tr>
</tbody>
</table>

### Description

<table>
<thead>
<tr>
<th>MAP UNITS</th>
<th>TTP06</th>
<th>TTP13</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typic Torripsamments consociation, rolling dunes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Suitability</strong></td>
<td><strong>Restr 1</strong></td>
<td><strong>Restr 2</strong></td>
</tr>
<tr>
<td><strong>S3</strong></td>
<td><strong>S2</strong></td>
<td><strong>S1</strong></td>
</tr>
<tr>
<td><strong>Restr 1</strong></td>
<td><strong>Restr 2</strong></td>
<td><strong>Restr 3</strong></td>
</tr>
</tbody>
</table>

### Irrigation

- **All-year crops with drip irrigation no more than 36,000 m³/ha.** Switch from flood irrigation to sprinkler or drip.

### Leaching (Desalination)

- **Target salinity maximum 1.5 x of irrigation water salinity; apply leaching fraction 14% to crop water requirements for drip and sprinkler irrigation.**
- **No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.**

### Crop Selection

- **Only extremely salt and alkalinity resistant crops:** Rhodes grass, Alfalfa, shallow rooting

### Fertilization

- **Moderate level, apply organic fertilizer for binding salinity.** Apply in low but frequent doses

### Drainage Control

- **Gypsum soil amendments when using desalinated water.**

### Alkalinity Control

- **Desalination plant, compost/manure, terrain levelling.**

### Meioration Measure

- **Desalination plant, compost/manure.**

---

**Figure 29: Soil Irrigation Suitability in Sweihan**
SOIL SALINITY MANAGEMENT PLAN

Al Dhafra (without Liwa): Silah, Al Marfa, Madinat Zayed, Ghayathi, Al Fadhiya

### Soil Existing Conditions

**Texture**
- Sand

**General Characteristics**
- Calcic, gypsic layers

**Rooting Depth**
- >150 cm

**Salinity**
- ECw 12,500 µS/cm high/low if desalinated

**Groundwater Presence**
- By leakage or over-irrigation

**Fertility**
- Low to medium

**Drainage**
- Well drained

**Permeability**
- Good

### Irrigation Water Existing Conditions

**Origin**
- Well water/desalinated water

**Salinity**
- ECw 1,500 µS/cm

**SAR**
- 17, high

**Available Quantity**
- Available

**Current Average Use (m3/irrigated ha)**
- 39,000, slightly high

### Table 14: Existing Conditions and Recommendations for Al Dhafra (without Liwa):
Silah, Al Marfa, Madinat Zayed, Ghayathi, Al Fadhiya
FIGURE 30: Soil Classification in Al Dhafra (I)

FIGURE 31: Soil Classification in Al Dhafra (II)
**SOIL SALINITY MANAGEMENT PLAN**

**Recommendations for Al Dhafra (without Liwa): Silah, Al Marfa, Madinat Zayed, Ghayathi, Al Fadihya**

<table>
<thead>
<tr>
<th>MAP UNITS</th>
<th>THC03</th>
<th>THC04</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td>Typic Haplocalcids - Typic Calcisols complex, deflation plains and low dunes</td>
<td>Typic Haplocalcids, Typic Haplocambids, alkaline deposits</td>
</tr>
<tr>
<td><strong>SUPTABILITY</strong></td>
<td><strong>RESTR 1</strong></td>
<td><strong>RESTR 2</strong></td>
</tr>
<tr>
<td><strong>IRRIGATION</strong></td>
<td>All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
<td>All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip</td>
</tr>
<tr>
<td><strong>LEACHING</strong></td>
<td>Target salinity maximum 1.5 x of irrigation water salinity; apply leaching fraction 16% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching</td>
<td>Target salinity maximum 1.5 x of irrigation water salinity; apply leaching fraction 16% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching</td>
</tr>
<tr>
<td><strong>CROP SELECTION</strong></td>
<td>Salinity and alkalinity resistant crops: Date palm, Rhodes Grass, Alfalfa. With good water quality vegetables, except alkalinity susceptible (citrus, beans, avocado, nuts)</td>
<td>Salinity and alkalinity resistant crops: Date palm, Rhodes Grass, Alfalfa. With good water quality vegetables, except alkalinity susceptible (citrus, beans, avocado, nuts)</td>
</tr>
<tr>
<td><strong>FERTILIZATION</strong></td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
<td>Moderate level, apply organic fertilizer for binding salinity</td>
</tr>
<tr>
<td><strong>DRAINAGE CONTROL</strong></td>
<td>Avoid irrigation beyond crop water requirement</td>
<td>Avoid irrigation beyond crop water requirement</td>
</tr>
<tr>
<td><strong>ALKALINITY CONTROL</strong></td>
<td>Gypsum soil amendments when using desalinated water</td>
<td>Gypsum soil amendments when using desalinated water</td>
</tr>
<tr>
<td><strong>MELIORATION MEASURE</strong></td>
<td>Desalination plant, apply compost/manure</td>
<td>Desalination plant, apply compost/manure</td>
</tr>
</tbody>
</table>

**Map Units**

<table>
<thead>
<tr>
<th>Total Farm Area</th>
<th>THC03</th>
<th>THC04</th>
</tr>
</thead>
<tbody>
<tr>
<td>343.4 ha</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>352.4 ha</td>
<td>9%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Farm Area</th>
<th>TTP39</th>
<th>TTP40</th>
</tr>
</thead>
<tbody>
<tr>
<td>511.4 ha</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>1,228.2 ha</td>
<td>33%</td>
<td></td>
</tr>
</tbody>
</table>

**Description**

**S2k SUITABILITY RESTR 1 RESTR 2 RESTR 3**

- **IRRIGATION**
  - All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip
  - Target salinity maximum 1.5 x of irrigation water salinity; apply leaching fraction 16% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching

**CROP SELECTION**

- Salinity and alkalinity resistant crops: Date palm, Rhodes Grass, Alfalfa. With good water quality vegetables, except alkalinity susceptible (citrus, beans, avocado, nuts)

**FERTILIZATION**

- Apply in low but frequent doses

**DRAINAGE CONTROL**

- Avoid irrigation beyond crop water requirement

**ALKALINITY CONTROL**

- Gypsum soil amendments when using desalinated water

**MELIORATION MEASURE**

- Desalination plant, apply compost/manure
SOIL SALINITY MANAGEMENT PLAN

Map Units

<table>
<thead>
<tr>
<th>TTP43s</th>
</tr>
</thead>
</table>

Total Farm Area

- 334.4 ha
- 9%

MAP UNITS

<table>
<thead>
<tr>
<th>TTP43s</th>
</tr>
</thead>
</table>

DESCRIPTION

Typic Torripsamments consociation, undulating to rolling rises and dunes, high salinity. Typic Torripsamments consociation, undulating to rolling rises and dunes, high salinity.

<table>
<thead>
<tr>
<th>SUITABILITY</th>
<th>RESTR 1</th>
<th>RESTR 2</th>
<th>RESTR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>S</td>
<td>t</td>
<td>n</td>
</tr>
</tbody>
</table>

IRRIGATION

All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip.

LEACHING (DESALINATION)

Target salinity maximum 1.5 x of irrigation water salinity: apply leaching fraction 16% to crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses). Use winter season for leaching.

CROP SELECTION

Salinity and alkalinity resistant crops: Date palm, Rhodes Grass, Alfalfa. With good water quality vegetables, except alkalinity susceptible (citrus, beans, avocado, nuts).

FERTILIZATION

Apply in low but frequent doses.

DRAINAGE CONTROL

Avoid irrigation beyond crop water requirement.

ALKALINITY CONTROL

Gypsum soil amendments when using desalinated water.

MELIORATION MEASURE

Desalination plant, ground leveling, apply compost/manure.

FIGURE 32: Soil Irrigation Suitability in Al Dhafra (I)
**SOIL SALINITY MANAGEMENT PLAN**

**FIGURE 33: Soil Irrigation Suitability in Al Dhafra (II)**

<table>
<thead>
<tr>
<th>Texture Origin</th>
<th>Salinity</th>
<th>Rooting Depth</th>
<th>Groundwater Presence</th>
<th>Fertility</th>
<th>Drainage</th>
<th>Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well water</td>
<td>ECw 7,000 µS/cm, low to medium</td>
<td>Available</td>
<td>Absent</td>
<td>Low</td>
<td>Excessive</td>
<td>Very good</td>
</tr>
<tr>
<td>ECe 4,000-8,000 µS/cm, moderate</td>
<td>Low</td>
<td>&gt;150 cm</td>
<td>Absent</td>
<td>Low</td>
<td>Excessive</td>
<td>Very good</td>
</tr>
</tbody>
</table>

**TABLE 15: Existing Conditions and Recommendations for Liwa North**

**IRRIGATION WATER EXISTING CONDITIONS**

<table>
<thead>
<tr>
<th>Origin</th>
<th>Salinity</th>
<th>SAR</th>
<th>Available Quantity</th>
<th>Current Average Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well water</td>
<td>ECw 7,000 µS/cm, low to medium</td>
<td>12, medium</td>
<td>Available</td>
<td>M3/IRRIGATED HA 52,000, high</td>
</tr>
</tbody>
</table>

**SOIL EXISTING CONDITIONS**

- **Liwa North**
SOIL SALINITY MANAGEMENT PLAN

**Recommendations for Liwa North**

### Map Units

<table>
<thead>
<tr>
<th>Map Units</th>
<th>TTP36s</th>
<th>TTP36t</th>
<th>TTP42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>5,835.3 ha</td>
<td>1,159.5 ha</td>
<td>3,263.6 ha</td>
</tr>
</tbody>
</table>

### Description

**SUITABILITY**

- **TTP42**
  - Typic Torripsamments consociation, undulating rises and valleys, agricultural use, low salinity

**RESTRICT**

- **TTP42**
  - TTP36s
    - All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip
  - TTP36t
    - All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip

### Irrigation

- **TTP36s**
  - All-year crops no more than 32,000 m³/ha for drip and sprinkler irrigation. Switch from flood irrigation to sprinkler or drip
  - Typic Torripsamments consociation, undulating rises and valleys, agricultural use, high salinity

### Leaching

- **TTP36s**
  - Not needed with regular irrigation
  - Suitable for all-year crops

### Crop Selection

- **TTP36s**
  - Salinity resistant crops, vegetables, except alkalinity susceptible: avocado, nuts, citrus
  - Suitable for all-year crops

### Fertilization

- **TTP36s**
  - Low fertilizer quantities in frequent doses, organic fertilizer
  - Suitable for all-year crops

### Drainage Control

- **TTP36s**
  - Not needed

### Alkalinity Control

- **TTP36s**
  - Gypsum soil amendments when using desalinated water
  - Suitable for all-year crops

### Melioration Measure

- **TTP36s**
  - Compost/manure, ground levelling
  - Suitable for all-year crops

---

**Figure 34: Soil Classification in Liwa North**

- Soil Classification in Agricultural Areas (Liwa North)
  - TTP42
  - TTP36t
  - TTP36s

---

**Total Farm Area**

- **TTP36s**
  - 1,159.5 ha (20%)
- **TTP36t**
  - 3,263.6 ha (56%)
- **TTP42**
  - 397.7 ha (7%)
SOIL SALINITY MANAGEMENT PLAN

FIGURE 35: Soil Irrigations Suitability in Liwa North

### TABLE 16: Existing Conditions and Recommendations for Liwa South

<table>
<thead>
<tr>
<th>Texture</th>
<th>Origin</th>
<th>Salinity</th>
<th>SAR</th>
<th>Available Quantity</th>
<th>Current Average Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Well water</td>
<td>ECw 22,000 µS/cm, high</td>
<td>22, high</td>
<td>Available</td>
<td>M3/Irrigated HA 57,000, high</td>
</tr>
</tbody>
</table>

### Liwa South

#### SOIL EXISTING CONDITIONS

- **Texture**: Sand
- **General Characteristics**: Levelled dunes
- **Rooting Depth**: >150 cm
- **Salinity**: ECe 8,000-40,000 µS/cm, medium to very high
- **Groundwater Presence**: By over-irrigation or leakage
- **Fertility**: Low
- **Drainage**: Excessive
- **Permeability**: Very good

#### IRRIGATION WATER EXISTING CONDITIONS

- **Origin**: Well water
- **Salinity**: ECw 22,000 µS/cm, high
- **SAR**: 22, high
- **Available Quantity**: Available
- **Current Average Use**: M3/Irrigated HA 57,000, high

**FIGURE 35**: Soil Irrigations Suitability in Liwa North

**TABLE 16**: Existing Conditions and Recommendations for Liwa South
SOIL SALINITY MANAGEMENT PLAN

Recommendations for Liwa South

**FIGURE 36: Soil Classification in Liwa South**

**Map Units**

<table>
<thead>
<tr>
<th>Map Units</th>
<th>TTP36s</th>
<th>TTP36t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Farm Area</td>
<td>7,550.7 ha</td>
<td>1,652.2 ha</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>TTP36s</th>
<th>TTP36t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUITABILITY</strong></td>
<td><strong>RESTRICTION</strong></td>
<td><strong>SUITABILITY</strong></td>
</tr>
<tr>
<td>53</td>
<td>RESTR 1</td>
<td>52</td>
</tr>
<tr>
<td>53</td>
<td>RESTR 2</td>
<td>52</td>
</tr>
<tr>
<td>53</td>
<td>RESTR 3</td>
<td>52</td>
</tr>
</tbody>
</table>

**IRRIGATION**

- All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip irrigation.
- Apply in winter months. Target salinity maximum 1.5 x of irrigation water salinity, apply 27% above crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses).

**LEACHING (DESALINATION)**

- All-year crops with drip irrigation no more than 32,000 m³/ha. Switch from flood irrigation to sprinkler or drip irrigation.
- Apply in winter months. Target salinity maximum 1.5 x of irrigation water salinity, apply 27% above crop water requirements for drip and sprinkler irrigation. No extra leaching needed for flood irrigation (high percolation losses).

**CROP SELECTION**

- Salinity and alkalinity resistant crops: Date palm, Rhodes grass, Alfalfa
- Moderately salinity resistant crops, vegetables, except alkalinety susceptible avocado, nuts, citrus

**FERTILIZATION**

- Low fertilizer quantities in frequent doses, organic fertilizer
- Low fertilizer quantities in frequent doses, organic fertilizer

**DRAINAGE CONTROL**

- Not needed
- Not needed

**ALKALINITY CONTROL**

- Gypsum soil amendments when using desalinated water
- Gypsum soil amendments when using desalinated water

**MELIORATION MEASURE**

- Desalination plant, terrain levelling, compost/manure
- Compost/manure, terrain levelling
FIGURE 37: Soil Irrigation Suitability in Liwa South
SECTION 3

TERMS OF SOIL, WATER AND CROP MANAGEMENT
SECTION 3: TERMS OF SOIL, WATER AND CROP MANAGEMENT

This section provides definitions for terms and expressions considered necessary to understand water and soil conditions. It further presents management recommendations for specific agricultural areas identified in the Emirate of Abu Dhabi.

LEACHING OF SALINITY

Ideally, salinity should be reduced to the level that secures optimum crop production. However, in practice, limitations are often imposed by the quality of irrigation water. To reduce salinity in the soil and to maintain its recommended levels — i.e. maximum 1.2 to 1.5 times the salinity of available irrigation water — an excess amount of irrigation water is needed.

SURFACE IRRIGATION

Surface Irrigation: The Leaching Requirement (LR) for surface irrigation is estimated using the following formula:

The Leaching Requirement is calculated using the equation of Rhoades (1974) and Rhoades and Merrill (1976), FAO (1985):

\[
LR (%) = \frac{ECe}{5(ECe) - ECw}
\]

Example:

ECw: 10,000
Required: ECe: 12,000 (1.2 times the salinity of irrigation water)

LR (%) = \frac{12,000}{5\times(12,000)-10,000} = 24%

or expressed as a fraction: 0.24

DRIP IRRIGATION

Drip Irrigation: Calculating the Leaching Requirement percentage for a Drip Irrigation System requires data on the electric conductivity of irrigation water (ECw) and the actual soil EC by saturation extract measured in the soil (ECe).

The Leaching Requirement is calculated using the equation of Rhoades (1974) and Rhoades and Merrill (1976), FAO (1985):

\[
LR (%) = \frac{ECw}{2*ECe}
\]

Example:

ECw: 10,000
Actual (measured) Soil Salinity ECe: 24,000

LR (%) = \frac{10,000}{2\times(24,000)} = 20.8%

or expressed as Leaching Fraction: 0.208
APPLICATION OF THE LEACHING REQUIREMENT

Once the desired leaching requirement (LR) and evapotranspiration (ET) demand of the crop becomes known, the net water required for such crop can be calculated (Ayers and Westcot 1985):

\[
\text{Net water requirement (including leaching)} = \frac{\text{ET}}{(1 - \text{LR})} 
\]

Where net water requirement equals depth of applied water (mm per year), ET equals total annual crop water demand (mm per year), and LR represents the leaching requirement expressed as a fraction (leaching fraction).

Example:
Al Ain:
Net plant requirement for date palms: 29,000 m³/ha annually
Required leaching percentage: 20% (or leaching fraction 0.2)

\[
\text{Net water requirement incl. leaching} = 29,000 \div 0.8 = 36,250 \text{ m}^3/\text{ha} 
\]

Effectively, an additional 7250 m³/ha need to be applied during the year. This percentage, or fraction, is applicable alongside the net normal irrigation water quantity on a yearly average. The winter season has a much lower irrigation requirement than the summer season. This can be leveraged to apply excess water for leaching during the winter to compensate for the lack of leaching during the summer.

The leaching requirement depends on the type of irrigation applied, while considering associated losses by infiltration, evaporation, and transport. For drip irrigation, where losses are reduced to a minimum, the chance of percolation and washing out of salts is reduced. The leaching fraction must therefore be applied in full. For sprinkler irrigation, and in order to have sufficient levels of water to percolate through the root zone, additional water must be applied in proportion to evaporation losses (30% of the leaching fraction).

For flood irrigation, where infiltration losses during field application are great (30 to 50%), especially considering the sandy soils of the Emirate of Abu Dhabi, no additional leaching water is needed to supplement the regular irrigation quantity. Percolation losses are sufficient to leach the salts.

IRRIGATION WATER QUALITY

The quality of irrigation water is detailed in the scale below. According to international norms issued by the Food and Agriculture Organization (FAO), water quality (Ayers RS, Westcot DW, 1985) beyond an EC of 3,000 µS/cm, (2,000 mg/l) progressively restricts crop growth.

The most salinity resistant crops such as Rhodes Grass or Date Palms are therefore reduced to less than 50% of production beyond a salinity of EC 25,000 µS/cm. (See crop tolerance and yield reduction in the table below).

<table>
<thead>
<tr>
<th>CATEGORIES</th>
<th>µS/cm</th>
<th>SALINITY LEVEL</th>
<th>FAQ RESTRICTION FOR CROPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0-2,000</td>
<td>Non-saline</td>
<td>Salinity effects are negligible</td>
</tr>
<tr>
<td>II</td>
<td>2,000-4,000</td>
<td>Very slightly saline</td>
<td>Yields of sensitive crops may be restricted</td>
</tr>
<tr>
<td>III</td>
<td>4,000-8,000</td>
<td>Moderately saline</td>
<td>Yields of many crops are restricted</td>
</tr>
<tr>
<td>IV</td>
<td>8,000-16,000</td>
<td>Strongly saline</td>
<td>Only tolerant crops yield satisfactorily</td>
</tr>
<tr>
<td>V</td>
<td>16,000-40,000</td>
<td>Very strongly saline</td>
<td>Only a few very tolerant crops yield satisfactorily</td>
</tr>
<tr>
<td>VI</td>
<td>&gt; 40,000</td>
<td>Extremely saline</td>
<td>Unsuitable for any crops</td>
</tr>
</tbody>
</table>

The Sodium Adsorption Rate (SAR) of irrigation water (the content of Sodium) affects susceptible plants beyond a value of 9%. Sodium susceptible plants are typically fruit trees, vegetables, and pulses.
SOIL SALINITY MANAGEMENT PLAN

The tolerance of various crops to Exchangeable-Sodium Percentage (ESP approx. equivalent to SAR, James et al., 1982) is highlighted below:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>MAGNITUDE</th>
<th>ESP</th>
<th>SODIUM HAZARD SUSCEPTIBLE PLANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Low</td>
<td>0-3</td>
<td>No hazard</td>
</tr>
<tr>
<td>S1</td>
<td>Low</td>
<td>3-9</td>
<td>Slight to moderate</td>
</tr>
<tr>
<td>S1</td>
<td>Low</td>
<td>&gt; 9</td>
<td>Severe</td>
</tr>
<tr>
<td>S2</td>
<td>Medium</td>
<td>10-18</td>
<td>Severe</td>
</tr>
<tr>
<td>S3</td>
<td>High</td>
<td>18-26</td>
<td>Severe</td>
</tr>
<tr>
<td>S4</td>
<td>Very High</td>
<td>&gt; 26</td>
<td>Severe</td>
</tr>
</tbody>
</table>

**TABLE 18: SAR Classes and Sodium Hazard (James et al., 1982)**

The table below details the expected yield decrease for selected plants according to variations in the quality of applied irrigation water. As a farmer selects crops, the available quality of irrigation water should be taken into account. The table is based on: Ayers & Westcot (1994): Crop tolerance and yield potential of selected crops as influenced by irrigation water salinity (ECw) or soil salinity (ECe) - Water Quality for Agriculture, FAO.

**ECe**: Average root zone salinity, measured as electrical conductivity of the saturation extract of the soil, reported in µS per centimeter (µS/cm) at 25°C.

**ECw**: Electrical conductivity of irrigation water in µS per centimeter (µS/cm).

The relationship between soil salinity and water salinity (ECe = 1.5 ECw) assumes a 15 - 20% leaching fraction and a 40 - 30 - 20 - 10% water use pattern for the upper to lower quarters of the root zone.

The zero-yield potential or maximum ECe indicates the theoretical soil salinity (ECe) at which crop growth ceases.

**CROP SELECTION ACCORDING TO WATER QUALITY**

**Extremely Sensitive**
ESP = 2 - 10
Deciduous fruits, nuts, citrus, avocado. Sodium toxicity symptoms

**Sensitive**
ESP = 10 - 20
Beans. Stunted growth at low ESP values even if the physical condition of the soil is good

**Moderately Tolerant**
ESP = 20 - 40
Clover, oats, tea, rice, dolphin grass. Stunted growth due to both adverse nutritional and soil conditions

**Tolerant**
ESP = 40 - 60
Wheat, cotton, alfalfa, barbry tomatoes, beets. Stunted growth, usually due to adverse physical soil conditions

**Most Tolerant**
ESP = > 60
Crested and fawny wheatgrass, tall wheatgrass, Rhodes grass. Stunted growth, usually due to adverse physical soil conditions
### CEREALS

<table>
<thead>
<tr>
<th>FIELD CROPS</th>
<th>100% ECw</th>
<th>90% ECw</th>
<th>75% ECw</th>
<th>50% ECw</th>
<th>0% No Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley (Hordeum vulgare)</td>
<td>8.0</td>
<td>5.3</td>
<td>10</td>
<td>6.7</td>
<td>13</td>
</tr>
<tr>
<td>Cotton (Gossypium hirsutum)</td>
<td>7.7</td>
<td>5.1</td>
<td>9.6</td>
<td>6.4</td>
<td>13</td>
</tr>
<tr>
<td>Sugarbeet (Beta vulgaris)</td>
<td>7.0</td>
<td>4.7</td>
<td>8.7</td>
<td>5.8</td>
<td>11</td>
</tr>
<tr>
<td>Sorghum (Sorghum bicolor)</td>
<td>6.8</td>
<td>4.5</td>
<td>7.4</td>
<td>5.0</td>
<td>8.4</td>
</tr>
<tr>
<td>Wheat (Triticum aestivum)</td>
<td>6.0</td>
<td>4.0</td>
<td>7.4</td>
<td>4.9</td>
<td>9.5</td>
</tr>
<tr>
<td>Wheat, durum (Triticum turgidum)</td>
<td>5.7</td>
<td>3.8</td>
<td>7.6</td>
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<td>10</td>
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<tr>
<td>Soybean (Glycine max)</td>
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<td>5.5</td>
<td>3.7</td>
<td>6.3</td>
</tr>
<tr>
<td>Cowpea (Vigna unguiculata)</td>
<td>4.9</td>
<td>3.3</td>
<td>5.7</td>
<td>3.8</td>
<td>7.0</td>
</tr>
<tr>
<td>Groundnut (Peanut) (Arachis hypogea)</td>
<td>3.2</td>
<td>2.1</td>
<td>3.5</td>
<td>2.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Rice (paddy) (Oryza sativa)</td>
<td>3.0</td>
<td>2.0</td>
<td>3.8</td>
<td>2.6</td>
<td>5.1</td>
</tr>
<tr>
<td>Sugarcane (Saccharum officinarum)</td>
<td>1.7</td>
<td>1.1</td>
<td>3.4</td>
<td>2.3</td>
<td>5.9</td>
</tr>
<tr>
<td>Corn (maize) (Zea mays)</td>
<td>1.7</td>
<td>1.1</td>
<td>2.5</td>
<td>1.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Fava (Linum usitatissimum)</td>
<td>1.7</td>
<td>1.1</td>
<td>2.5</td>
<td>1.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Broadbean (Vicia faba)</td>
<td>1.5</td>
<td>1.1</td>
<td>2.6</td>
<td>1.8</td>
<td>4.2</td>
</tr>
<tr>
<td>Bean (Phaseolus vulgaris)</td>
<td>1.0</td>
<td>0.7</td>
<td>1.5</td>
<td>1.0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

### VEGETABLE CROPS

<table>
<thead>
<tr>
<th>FIELD CROPS</th>
<th>100% ECw</th>
<th>90% ECw</th>
<th>75% ECw</th>
<th>50% ECw</th>
<th>0% No Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squash, zucchini (courgette) (Cucurbita pepo melopepo)</td>
<td>4.7</td>
<td>3.1</td>
<td>5.8</td>
<td>3.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Beet, red (Beta vulgaris)</td>
<td>4.0</td>
<td>2.7</td>
<td>5.1</td>
<td>3.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Squash, scallop (Cucurbita pepo melopepo)</td>
<td>3.2</td>
<td>2.1</td>
<td>3.8</td>
<td>2.6</td>
<td>4.8</td>
</tr>
<tr>
<td>Broccoli (Brassica oleracea botrytis)</td>
<td>2.8</td>
<td>1.9</td>
<td>3.9</td>
<td>2.6</td>
<td>5.5</td>
</tr>
<tr>
<td>Tomato (Lycopersicon esculentum)</td>
<td>2.5</td>
<td>1.7</td>
<td>3.5</td>
<td>2.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Cucumber (Cucumis sativus)</td>
<td>2.5</td>
<td>1.7</td>
<td>3.3</td>
<td>2.2</td>
<td>4.4</td>
</tr>
<tr>
<td>Spinach (Spinacia oleracea)</td>
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<td>1.3</td>
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<td>2.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Celery (Apium graveolens)</td>
<td>1.8</td>
<td>1.2</td>
<td>3.4</td>
<td>2.3</td>
<td>5.8</td>
</tr>
<tr>
<td>Cabbage (Brassica oleracea capitata)</td>
<td>1.8</td>
<td>1.2</td>
<td>2.8</td>
<td>1.9</td>
<td>4.4</td>
</tr>
<tr>
<td>Potato (Solanum tuberosum)</td>
<td>1.7</td>
<td>1.1</td>
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<td>3.8</td>
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<tr>
<td>Corn, sweet (maize) (Zea mays)</td>
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<td>1.1</td>
<td>2.5</td>
<td>1.7</td>
<td>3.8</td>
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<tr>
<td>Sweet potato (Ipomoea batatas)</td>
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<td>1.0</td>
<td>2.4</td>
<td>1.6</td>
<td>3.8</td>
</tr>
<tr>
<td>Pepper (Capsicum annuum)</td>
<td>1.5</td>
<td>1.0</td>
<td>2.2</td>
<td>1.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Lettuce (Lactuca sativa)</td>
<td>1.3</td>
<td>0.9</td>
<td>2.1</td>
<td>1.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Radish (Raphanus sativus)</td>
<td>1.2</td>
<td>0.8</td>
<td>2.0</td>
<td>1.3</td>
<td>3.1</td>
</tr>
<tr>
<td>Onion (Allium cepa)</td>
<td>1.2</td>
<td>0.8</td>
<td>1.8</td>
<td>1.2</td>
<td>2.8</td>
</tr>
<tr>
<td>Carrot (Daucus carota)</td>
<td>1.0</td>
<td>0.7</td>
<td>1.7</td>
<td>1.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Bean (Phaseolus vulgaris)</td>
<td>1.0</td>
<td>0.7</td>
<td>1.5</td>
<td>1.0</td>
<td>2.3</td>
</tr>
</tbody>
</table>
### VEGETABLE CROPS

<table>
<thead>
<tr>
<th>Field Crops</th>
<th>100%</th>
<th>90%</th>
<th>75%</th>
<th>50%</th>
<th>0% No Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnip (Brassica rapa)</td>
<td>0.9</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Wheatgrass, tall (Agropyron elongatum)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Wheatgrass, fairway crested (Agropyron cristatum)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Bermuda grass (Cynodon dactylon)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Barley (Hordeum vulgare)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Ryegrass, perennial (Lolium perenne)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Trefol, narrowleaf birdsfoot (Lotus corniculatus tenuifolium)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Harding grass (Phalaris tuberosa)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Fescue, tall (Festuca elatior)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
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<tr>
<td>Wheatgrass, standard crested (Agropyron sibiricum)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
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<tr>
<td>Vetch, common (Vicia angustifolia)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Sudan grass (Sorghum sudanense)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Wildrye, beardless (Elymus triticoides)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Cowpea (forage) (Vigna unguiculata)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Trefol, big (Lotus uliginosus)</td>
<td>5.0</td>
<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Sesbania (Sesbania exaltata)</td>
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<td>2.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
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</tbody>
</table>
TABLE 19: Decreasing Crop Yield Levels as Salinity Increases

<table>
<thead>
<tr>
<th>Fruit Crops</th>
<th>ECe</th>
<th>ECw</th>
<th>ECe</th>
<th>ECw</th>
<th>ECe</th>
<th>ECw</th>
<th>ECe</th>
<th>ECw</th>
<th>ECe</th>
<th>ECw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date palm (Phoenix dactylifera)</td>
<td>4.0</td>
<td>2.7</td>
<td>6.8</td>
<td>4.5</td>
<td>11.7</td>
<td>7.3</td>
<td>18.0</td>
<td>12.1</td>
<td>32</td>
<td>21</td>
</tr>
<tr>
<td>Grapefruit (Citrus paradisi)</td>
<td>1.8</td>
<td>1.2</td>
<td>2.4</td>
<td>1.6</td>
<td>3.4</td>
<td>2.2</td>
<td>4.9</td>
<td>3.3</td>
<td>8.0</td>
<td>5.4</td>
</tr>
<tr>
<td>Orange (Citrus sinensis)</td>
<td>1.7</td>
<td>1.1</td>
<td>2.3</td>
<td>1.6</td>
<td>3.3</td>
<td>2.2</td>
<td>4.8</td>
<td>3.2</td>
<td>8.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Peach (Prunus persica)</td>
<td>1.7</td>
<td>1.1</td>
<td>2.2</td>
<td>1.5</td>
<td>2.9</td>
<td>1.9</td>
<td>4.1</td>
<td>2.7</td>
<td>6.5</td>
<td>4.3</td>
</tr>
<tr>
<td>Apricot (Prunus armeniaca)</td>
<td>1.6</td>
<td>1.1</td>
<td>2.0</td>
<td>1.3</td>
<td>2.6</td>
<td>1.8</td>
<td>3.7</td>
<td>2.5</td>
<td>5.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Grape (Vitis sp.)</td>
<td>1.5</td>
<td>1.0</td>
<td>2.5</td>
<td>1.7</td>
<td>4.1</td>
<td>2.7</td>
<td>6.7</td>
<td>4.5</td>
<td>12</td>
<td>7.9</td>
</tr>
<tr>
<td>Almond (Prunus dulcis)</td>
<td>1.5</td>
<td>1.0</td>
<td>2.0</td>
<td>1.4</td>
<td>2.8</td>
<td>1.9</td>
<td>4.1</td>
<td>2.8</td>
<td>6.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Plum, prune (Prunus domestica)</td>
<td>1.5</td>
<td>1.0</td>
<td>2.1</td>
<td>1.4</td>
<td>2.9</td>
<td>1.9</td>
<td>4.3</td>
<td>2.9</td>
<td>7.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Blackberry (Rubus sp.)</td>
<td>1.5</td>
<td>1.0</td>
<td>2.0</td>
<td>1.3</td>
<td>2.6</td>
<td>1.8</td>
<td>3.8</td>
<td>2.5</td>
<td>6.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Boysenberry (Rubus ursinus)</td>
<td>1.5</td>
<td>1.0</td>
<td>2.0</td>
<td>1.3</td>
<td>2.6</td>
<td>1.8</td>
<td>3.8</td>
<td>2.5</td>
<td>6.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Strawberry (Fragaria sp.)</td>
<td>1.0</td>
<td>0.7</td>
<td>1.3</td>
<td>0.9</td>
<td>1.8</td>
<td>1.2</td>
<td>2.5</td>
<td>1.7</td>
<td>4.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

**CRUST BREAKING, MULCHING, ORGANIC FERTILIZER**

Salt dissolved in the soil, and carried in irrigation water, has a tendency to move upwards by capillary action (similar to coffee rising in a cube of sugar) to the soil surface. Breaking the soil layers of the surface crust disrupts the capillary pores and the rising of salts. The incorporation of organic substance (mulching) with compost and manure further inhibits this tendency and provides a fertilizing effect.

**FERTILIZATION**

Special problems are encountered when trying to fertilize an arid climate with saline water and sandy textures.

Most Nitrogen fertilizers are produced as salts and, when applied, tend to aggravate the problem of salinity. An exception is noted for the use of Nitrogen in the form of Urea, which can in fact be recommended. Nonetheless, Nitrogen should also be applied in a pH neutral form (e.g. Calcium Ammonium Nitrate). Acid forms of Nitrogen tend to dissolve as carbonates and gypsum, which should be avoided (subsidence). On the other hand, Potassium is usually naturally contained in irrigation water, with the exception of desalinated water where it is added in water soluble form based on fertilization recommendations. Phosphates have limited solubility in water; except for various grades of Superphosphates, which can be mixed into irrigation water and applied as needed.
CROP WATER REQUIREMENTS

Water is a scarce commodity. Even when provided free of charge, pumping and application costs are still a real consideration. Furthermore, and while it is evident that the rational use of water is beneficial for the environment, such rationing also carries economic significance. Therefore, applying crop water requirements effectively means reaching the best compromise between a good plant yield, water conservation, serving the environment, and reducing irrigation costs. The table below highlights the clear advantage of using drip irrigation compared to sprinkler or flood irrigation when it comes to irrigation efficiency (reducing losses by infiltration and evaporation).

Furthermore, the application of saline water brings salts into the soil. The excess salt consequently needs to be washed out with leaching water.

FOR EXAMPLE, WITH AN IRRIGATION WATER QUALITY OF 15,000 μS/CM (9,600 MG/L) AND A USUAL IRRIGATION RATE OF 35,000 M³/HA PER YEAR (PALM TREES), A 33.6 KG/M² OF SALT IS DEPOSITED. THE AMOUNTS OF SALT DEPOSITED INTO THE SOIL SHOULD THEREFORE BE LIMITED BY REDUCING IRRIGATION TO THE CLIMATIC CROP WATER REQUIREMENT.

The calculation is based on Abu Dhabi climatological data recorded over the last ten years and made available by the National Centre for Meteorology and Seismology (2017), and on Crop Water Requirements (Dorenboos J. and Pruitt, W.O., 1996). Typical Crop Water Requirements (gross requirement that caters for typical losses for drip, sprinkler or flood irrigation) for the three regions in Abu Dhabi are detailed for main all-year crops.
SOILS WITH DRAINAGE PROBLEMS, OVER-IRRIGATION

Another problem encountered at the root level, that also hinders free water drainage, is the presence of soils with an impermeable layer within their rooting depth such as rock, calcareous or gypsiferous hardpans. Free drainage is important, as is the lack of stagnant water in the root zone, and this to avoid ascending capillary salinization from the perched water level. Drainage can be improved by using hardpan breaking equipment, for example, by ripping drainage lines into the hardpan at horizontal distances from 3 to 5 m. Underground leakage in the irrigation pipes may also contribute to local drainage problems, and therefore to salinity.

GYPSUM FOR NON-SALINE SODIC SOILS

Soils with high SAR and high salinity are usually unaffected by infiltration problems. However, toxicity for Sodium susceptible plants (fruits, vegetables, beans) is a serious issue and may lead to the exclusion of such plants from the cropping pattern (see SAR above).

Under normal salt leaching procedures, the SAR is reduced to a harmless level. But when desalinated irrigation water is applied, this could lead to a SAR problem due to the residual enrichment of Sodium. In this case, additional sources of Calcium must be provided. High SAR values are indicated by a high pH value (>8.8). Based on the identified pH, the following melioration measures may be implemented:

**SOILS WITH DRAINAGE PROBLEMS, OVER-IRRIGATION**

REAL APPLICATION RATES IN THE EMIRATE OF ABU DHABI (35,000 UP TO 85,000 M³/HÅ), AS MEASURED IN THE FIELD, CLEARLY EXCEED CALCULATED GROSS WATER REQUIREMENTS, ESPECIALLY FOR FLOOD AND SPRINKLER IRRIGATION. THIS OUTCOME CONSEQUENTLY CALLS FOR THE ADEQUATE USE OF DRIFF IRRIGATION, AN ADDITIONAL LEACHING REQUIREMENT OF 20 TO 30% IS NECESSARY ONLY WHEN WATER-SAVING DRIFF IRRIGATION IS USED.

**TABLE 20:** Net and Gross Crop Water Requirements for Alfalfa, Rhodes Grass and Date palm in Three Regions in Abu Dhabi; Irrigation Efficiencies with Drip, Sprinkler and Flood Irrigation Calculations Based on Abu Dhabi Climatological Data and Crop Water Requirements (Dorenboos J. and Pruitt, W.O., 1996).

**TABLE 21:** Gypsum Requirement for Sodic Soils (Abrol, Dargan and Bhumbla, 1973)

**CROP ROTATION AND FALLOW FOR SOIL RECUPERATION**

The conducted field survey revealed that farm surfaces that had been fallow for some years were noticeably less saline than irrigated areas. This result could be attributed to a natural and slow desalization process that occurs in sandy soils catalyzed by natural precipitation and dew. In such cases, it is recommended to give the soil an opportunity to recover.
IRRIGATION SUITABILITY

Along with soil mapping and classification, the UAESIS survey provided an evaluation of soil suitability for the development of irrigated agriculture.

The adopted evaluation follows the land suitability classification concepts developed by the FAO in its Framework for Land Evaluation (FAO 1976). The FAO system is generally recognized as a benchmark for land evaluation and has been used as the basis for specific land evaluation applications such as irrigated agriculture (FAO 1985).

Below is an overview of the soil characteristics associated with the various ratings:

**S1**
Land that is highly suitable for irrigated agriculture.
The soil in this category is able to sustainably produce high yields for a wide variety of climatically adapted crops. The soils are nearly level and well drained; and are deep, with a fine sandy texture or a finer, single-grained texture. This allows for easy root penetration and for the retention of abundant air and water in the root zone. The soils have low soluble salts, sodicity, gypsum content, and calcium carbonate content and a neutral pH. Soils that form part of this category in Abu Dhabi have a lighter texture and contain more gravel and carbonate than other locations considered to be highly suitable. However these criteria are appropriate for a range of soils available in the Emirate.

**S2**
Land of moderate suitability for irrigated agriculture.
The soil in this category has an inherently lower productive capacity compared with S1 soils. The quality of soils and lands in this category may restrict irrigation but such restrictions can be corrected or compensated for relatively easily. S2 soils in Abu Dhabi have a sandy texture and are single grain or massive. They are deep and somewhat excessively or well drained. These soils are typically very slightly saline, non-sodic, have low gypsum content, and can have a hummocky microrelief. Appropriate management strategies can help overcome these moderate restrictions.

**S3**
Land of marginal suitability for irrigated agriculture.
The soil in this category has a lower productive capacity compared with S1 and S2 soils. It presents severe limitations that could be corrected with the implementation of appropriate management strategies. Soils that fall under this category in Abu Dhabi are moderately deep with a hardpan or water table occurring within 100-150 cm from the soil surface. They have a sand to a sandy loam texture and are single-grained or massive. They are typically slightly saline to saline and have moderate gypsum contents. These soils may have a moderately steep gradient (up to 32%) with a moderately high relief (up to 9 meters).

**NI**
Land that is currently unsuitable for irrigated agriculture.
Soils that fall under this category in Abu Dhabi typically have shallow rooting depths with hardpans within 50 – 100 cm of the soil surface. They also have a high gypsum content close to the surface, are saline or have a high relief (up to 30 m) and a steep gradient (up to 56%).

**N2**
Land considered permanently unsuitable for irrigated agriculture.
The soil in this category has an inherently lower productive capacity compared with S1 soils. The quality of soils and lands in this category may restrict irrigation but such restrictions can be corrected or compensated for relatively easily. S2 soils in Abu Dhabi have a sandy texture and are single grain or massive. They are deep and somewhat excessively or well drained. These soils are typically very slightly saline, non-sodic, have low gypsum content, and can have a hummocky microrelief. Appropriate management strategies can help overcome these moderate restrictions.
<table>
<thead>
<tr>
<th>SOIL CHARACTERISTIC</th>
<th>LIMITATION CODE</th>
<th>RATING CATEGORIES</th>
<th>RESTRICTIVE FEATURE</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardpan or rock depth, cm</td>
<td>m</td>
<td>S1</td>
<td>S2</td>
<td>S3</td>
</tr>
<tr>
<td>Water table depth, cm</td>
<td>w</td>
<td>S1</td>
<td>S2</td>
<td>S3</td>
</tr>
<tr>
<td>Salinity (EC 1:1 weight/volume), avg. 50-0 cm</td>
<td>z</td>
<td>13.0</td>
<td>&gt;1.3</td>
<td>&gt;2.7</td>
</tr>
<tr>
<td>Gypsum- depth to upper boundary of gypsic diagnostic horizon</td>
<td>y</td>
<td>S1</td>
<td>S2</td>
<td>S3</td>
</tr>
<tr>
<td>Texture for 25-0cm layer</td>
<td>t</td>
<td>IS1, IS5, vIS, vS</td>
<td>S</td>
<td>Too sandy</td>
</tr>
<tr>
<td>Texture for 25-0cm layer</td>
<td>t</td>
<td>sCL</td>
<td>S</td>
<td>Too clayey</td>
</tr>
<tr>
<td>Slope gradient%</td>
<td>S</td>
<td>1 - 0</td>
<td>&gt;3.1</td>
<td>&gt;3.2</td>
</tr>
<tr>
<td>Relief, height above surrounding area, m</td>
<td>r</td>
<td>1 - 0</td>
<td>&gt;3.1</td>
<td>&gt;3.9</td>
</tr>
</tbody>
</table>

**TABLE 22: Soil Rating Criteria Based on the FAO System (1976, 1985).**
OUTLOOK AND RECOMMENDATIONS
OUTLOOK AND RECOMMENDATIONS

Water resources in the Emirate of Abu Dhabi face severe risks of depletion and quality deterioration. Meanwhile, farms are experiencing a lack of good irrigation water and are consequently facing the salinization of their soil resources. This has led to the widespread temporary fallow (40%) of farmlands. More than 80% of agricultural soils in the Emirate are affected by soil salinity.

As for factors influencing soil salinity, they mainly include precipitation, leaching processes, the capillary ascent of dissolved salts, irrigation management, heavy textures, and impermeable layers. Furthermore, the incorrect disposal of brine on farms from desalination units has become a growing concern as the number of desalination units on farms rises rapidly.

FARM IRRIGATION MANAGEMENT

It should be noted that, based on a comparison of irrigation water and soil salinity, most farms (75%) are well managed. However, most farms can still improve their irrigation management when it comes to crop patterns, groundwater use, and tillage. Accepted rules for good farm management include:

- Leaching out accumulated salts during the cooler and wetter seasons of the year, when evaporation levels are low.
- Breaking crusts on the soil surface and covering the surface with mulch to prevent capillary action that leads to evaporation and salt deposition at the surface.
- Avoiding over irrigation during the summer to avoid salt deposition.
- Selecting crops based on the available quality of irrigation water and soil.
- Using available good groundwater resources and desalinated seawater for high-value crops. Saline groundwater should be used for more salt tolerant crops while TSE should be used whenever possible. However, TSE use should be limited to cases where it does not come into contact with products designated for direct human consumption. It can be safely used for landscapes and fruit tree irrigation.

Further recommendations are provided below to help mitigate soil salinity and maintain the usefulness of soils for more sustainable agricultural practices:

- Controlling brine disposal at desalination plants to guarantee correct processes are followed.
- Implementing more efficient irrigation practices, e.g., drip irrigation.
- Avoiding irrigation beyond crop water requirements during the summer to avoid salt deposition, perched water tables and the capillary rise of salts.
- Leveraging the recognized positive effect of organic fertilizers to attenuate the effect of salinity and alkalinity.
- For non-saline sodic soils, applying gypsum amendments according to the identified pH.
- For annual crops, applying crop rotation within the farm, i.e., leave a proportion of the surface fallow for some years to give the soil a chance to revert to lower salinity levels.
LONG-TERM SOIL SALINITY MONITORING

Soil salinity monitoring was established during this project. It is recommended that such monitoring continues throughout the coming years on a biannual basis in order to assess seasonal changes in soil salinity and long-term changes in soil salinity, and to optimize farm irrigation management.

The observation of long-term changes in agricultural soils can lead to the establishment of key performance indicators. Such KPIs are necessary to develop a nationwide concept for the optimal use of available water and soil resources. Building on this scientific basis, decision makers can develop meaningful and valuable policies and regulations.

SOIL MANAGEMENT PLAN

The Soil Management Plan provides recommendations for every Irrigation District in the Emirate of Abu Dhabi. Together with the soil suitability map and groundwater quality data, the soil management plan can form the basis of discussions with ADAFSA and other stakeholders for any future development of agriculture in the Emirate. Further to the plan, recommended measures should be initiated and implemented in cooperation with stakeholders.

SOIL CLASSIFICATION

Together, the extensive soil survey, the intensive soil survey, and the current farmland soil survey provide a comprehensive database for the soils available in the Emirate of Abu Dhabi. The survey approach, classification scheme, and the UAESIS database can also serve as a standard reference for similar soil surveys to be conducted in the other Emirates.
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