Worldwide Expertise for Food & Flowers

Final Report

Salinity RoadMap – Egypt

Attribution and Acknowledgement

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The Salt Doctors BV

The Salt Doctors is a Dutch research and knowledge company specialized in salinity assessments, monitoring, and the design of practical solutions for agriculture under saline conditions. They combine scientific expertise with hands-on field experience to deliver practice-ready strategies that improve soil health, crop productivity, and water-use efficiency, either adapting to salinity, or mitigating the salinity effects as much as possible. Their work ranges from risk mapping and monitoring frameworks to the development of integrated practical solutions that help farmers adapt to saline environments in a cost-effective and sustainable manner. Their activities in Egypt are spread out over more than ten years, spanning 14 different projects all over the country.

Disclaimer

The views expressed in the report are those of the authors and do not necessarily reflect the official policy of the Dutch Government.

Abstract

Salinity has rapidly become one of the most critical threats to agricultural productivity, water security, and rural livelihoods in Egypt. As this report demonstrates, salinity is not a uniform phenomenon, but a multidimensional challenge shaped by four distinct mechanisms: irrigation-driven salinity, drainage- and groundwater-driven salinity, coastal and climate-induced salinity, and primary (geogenic) salinity. Each mechanism interacts differently with Egypt's diverse agro-ecological zones, influencing soil conditions, crop performance, and water management requirements. Despite decades of investments in land reclamation, drainage infrastructure, and irrigation modernization, salinity smart agriculture has not been widely scaled. Fragmented interventions limited institutional coordination, insufficient monitoring systems, and the absence of integrated approaches have hindered national progress.

This report synthesizes extensive literature, and stakeholder interviews and consultations to assess the scale of the salinity challenge and identify actionable priorities for intervention. It proposes a comprehensive framework organized around five pillars: (1) drainage infrastructure and governance, (2) irrigation modernization and planned leaching, (3) soil health and integrated agronomy, (4) cropping system diversification and protected agriculture, and (5) monitoring, data harmonization, and policy integration. These pillars are complemented by cross-cutting recommendations that emphasize public–private partnerships, targeted financial incentives, and enhanced coordination at governorate and national levels. The 2035 Salinity Roadmap presented in the report outlines a realistic pathway toward a climate-resilient agricultural system in which salinity risks are routinely diagnosed, farmers adopt integrated mitigation packages, drainage systems are adequately maintained, and coastal salinity is addressed through long-term adaptation strategies.

Dutch expertise adds significant value to this national effort. With globally recognized strengths in saline agriculture, delta management, drainage engineering, and climate-smart solutions, Dutch institutions and companies are well positioned to support Egypt in designing scalable, data-driven, and commercially viable interventions. The Salinity Roadmap Egypt project,

commissioned by the Netherlands Food Partnership and the Embassy of the Kingdom of the Netherlands in Cairo, aims to consolidate these insights into a national, evidence-based roadmap that aligns technical, institutional, and market dimensions. By integrating science, policy, and practice, the roadmap provides a strategic foundation for building a productive, resilient, and economically competitive agricultural sector for the future.

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Introduction

Egypt’s agricultural sector has historically depended on the Nile River and its fertile delta, which remain central to national food security and rural livelihoods. Irrigated agriculture along the Nile has shaped settlement patterns and production systems for centuries, making water management a cornerstone of agricultural sustainability (Abdel-Dayem, 1987; Swain, 2014). Today, agriculture contributes approximately 13–14% to Egypt’s GDP and employs nearly one-fifth of the labor force, underscoring its socio-economic importance (El Attar et al., 2023). However, this foundation is increasingly under pressure. Among the most serious and growing challenges is soil and water salinity. Salinization is widely recognized as a major constraint to sustainable agriculture in arid and semi-arid regions and is particularly acute in Egypt (FAO, 2019; Abdel-Rahman and Belal, 2023). Salinity threatens productivity in both long-established Delta lands and newly reclaimed desert areas, where irrigation expansion often occurs under marginal water and soil conditions (Mohamed, 2016; van Halsema and El Gendy, 2024).

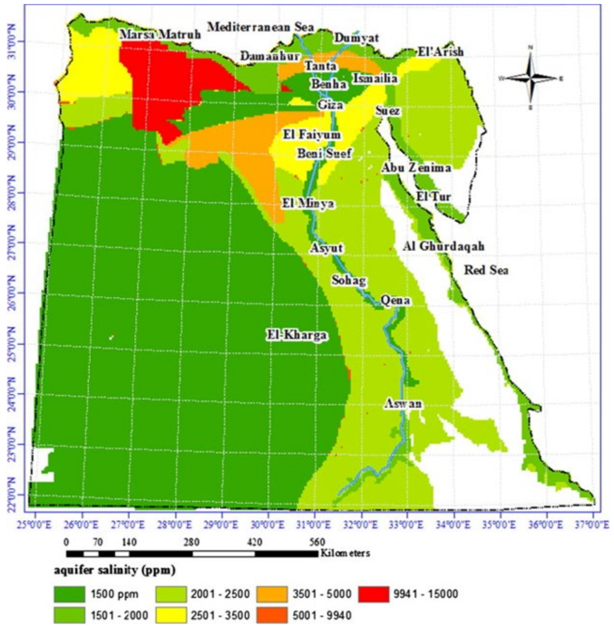

Figure 1: Classification of aquifer salinity in Egypt (Salim, 2011)

The drivers of salinity in Egypt are multiple and closely interlinked. They include seawater intrusion into coastal aquifers, inadequate or aging drainage systems, inefficient irrigation practices, and the reuse of increasingly saline drainage water (Abdel-Dayem, 1987; El-Ghannam et al., 2023). These pressures are compounded by Egypt's arid climate and very limited rainfall, with most regions receiving minimal and highly variable precipitation. As shown in *Figure 2*, Meaningful rainfall is largely confined to the northern coastal areas, while the majority of the country receives negligible amounts. This scarcity of rainfall reduces natural leaching of salts from the soil profile and increases dependence on irrigation, both of which contribute to salinity buildup.

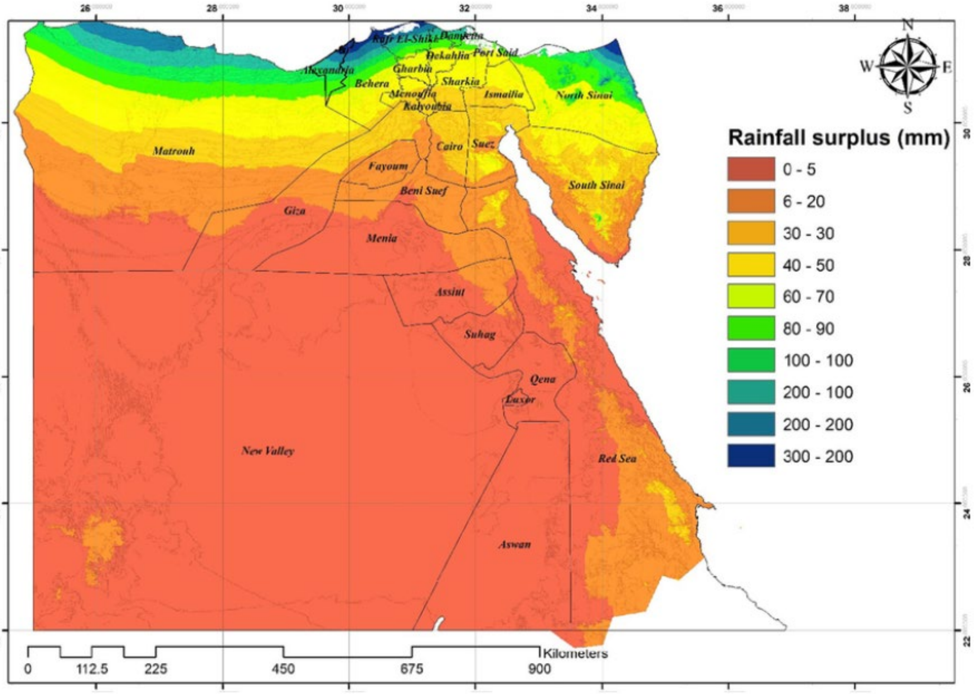

Figure 2: Rainfall surplus map for Egypt

Climate change adds further stress through sea level rise, higher temperatures, and increased evapotranspiration, all of which accelerate salt accumulation in soils and groundwater (Elbana *et al.*, 2024; IPDC Secretariat, 2025).

Salinity management is directly aligned with Egypt’s new economic narrative, officially launched on 7 September 2025 as an initiative by the Ministry of Planning and Economic Development and aligns with Egypt vision 2030. The narrative emphasizes high-productivity sectors, export growth, private-sector empowerment, and a green transition. Agriculture is one of the core productive sectors highlighted in the Narrative for Economic Development, and salinity is among the most critical constraints limiting its competitiveness, export potential, and ability to attract private investment. Addressing salinity is therefore not only an environmental necessity but also an economic reform priority that supports Egypt’s goals of increasing foreign-exchange earnings, improving productivity, protecting infrastructure investments, and advancing climate-resilient, private-sector–led growth.

Within this context, the Salinity Roadmap Egypt project was initiated. Commissioned by the Netherlands Food Partnership (NFP) and the Embassy of the Kingdom of the Netherlands in Cairo, and executed by Delphy in collaboration with The Salt Doctors, the project aims to deliver a nationally owned, evidence-based roadmap for salinity management that connects technical solutions with policy frameworks and market opportunities. The roadmap is designed to serve as a strategic guide for government institutions, research organizations, private-sector actors, and development partners—enabling coordinated action to mitigate salinity risks and strengthen the resilience and competitiveness of Egypt’s agricultural sector.

Methodology

The methodology underpinning this report combines desk-based research with participatory approaches. A literature review—referred to as the situation analysis and needs assessment—established an evidence base on salinity dynamics, management practices, and policy frameworks in Egypt. This review covered scientific studies on soil and water salinity, irrigation efficiency, drainage performance, and climate-related impacts, as well as national strategies such as the Sustainable Agricultural Development Strategy 2030 and the National Water Resources Plan. In parallel, stakeholder interviews were conducted with experts from government ministries, research centers, academia, and the private sector. These semi-structured interviews explored salinity hotspots, underlying causes, farmer constraints, existing mitigation practices, and policy gaps. To validate and enrich these findings, the project team also participated in specialized workshops, including sessions organized by the Egyptian Center of Excellence for Saline Agriculture and Cairo Water Week in October 2025. Together, these engagements ensured that the roadmap reflects both scientific evidence and practical realities on the ground.

Figure 3: Overview of the data-collection methodology

Figure 3 presents an overview of the data-collection methodology. The literature review and stakeholder interviews were conducted in parallel, and their findings were subsequently validated through a stakeholder workshop. This iterative approach allowed insights from one phase to inform and refine the others, strengthening the overall evidence base.

Study limitations

This study faced several limitations that should be acknowledged when interpreting the findings:

1. **Limited availability of recent agricultural data**
   Some national and regional agricultural statistics were outdated or unavailable. As a result, the study relied on literature sources and stakeholder interviews to fill data gaps, which may not fully capture the most recent developments.
2. **Limited private sector availability**
   Private sector stakeholders were occasionally difficult to engage during the study period, as it coincided with the winter agricultural season (October–March), which is a key production period in Egypt. During this time, many actors are heavily involved in

operational activities. This reduced availability for interviews and workshops and may have limited the diversity of private sector perspectives captured.

3. **Scope of the validation workshop**
   The validation workshop in December 2025, generated valuable insights; however, time constraints limited the opportunity to explore some topics in greater depth. As a result, certain issues may require further discussion in future engagements.
4. **Inconsistent or outdated salinity data**
   Available datasets on soil and water salinity were sometimes incomplete, outdated, or inconsistent across sources. This affects the precision of salinity assessments and highlights the need for improved monitoring and data harmonization.
5. **Private sector data sensitivity**
   Some companies were reluctant to share commercially sensitive information related to markets, operations, or investment plans. This limited the ability to conduct detailed market sizing, use-case development, and economic analysis.

Despite these limitations, this report brings together the findings and recommendations generated through a structured, multi-phase process. It opens with a comprehensive situation analysis based on recent scientific literature and policy documents to assess the extent, drivers, and impacts of salinity across Egypt. This is complemented by insights from stakeholder interviews and validation workshops, which provide practical perspectives on constraints, institutional gaps, and priority interventions. The report presents a bottleneck assessment identifying technical, financial, and governance barriers to scaling effective salinity management solutions. It also examines market opportunities for innovative technologies and services, highlighting areas where Dutch expertise can support Egyptian priorities. Together, these elements provide the foundation for a strategic roadmap that is both technically sound and institutionally feasible, enabling coordinated action toward more resilient and productive agricultural systems.

1. Situation analysis and needs assessment

1.1 Comprehensive desk review

1.1.1 Nature and extent of salinity and water scarcity in Egypt

Salinity represents one of the most persistent and complex challenges affecting Egypt's water and agricultural systems. Operating within an arid climatic context characterized by high evapotranspiration and limited freshwater availability, Egypt's agricultural production relies heavily on intensive irrigation and reuse of water resources. Under these conditions, salts naturally present in soils, surface water, and groundwater tend to accumulate over time, particularly where water management and drainage capacity are constrained (Qadir & Oweis, 2020; Mwesige, 2025).

Scientific literature consistently emphasizes that salinity in Egypt does not arise from a single cause, but from the interaction of climatic, hydrological, and management-related factors. High evapotranspiration rates promote salt concentration in soils and shallow groundwater, while long-term irrigation and reuse of drainage water contribute to the gradual build-up of salts across irrigated landscapes. In parallel, limited or deteriorating drainage infrastructure in parts of the Nile Delta restricts the natural leaching of salts, allowing salinity to persist and expand spatially (MALR, 2009; Tawfik et al., 2024; IFAD, 2025). These interacting processes highlight that salinization is best understood as a systemic phenomenon rather than as an isolated agronomic problem.

Estimates of the extent of salinity reflect its national significance. Recent studies suggest that approximately 30–35 percent of Egypt's irrigated land is affected by salinity to varying degrees, with higher concentrations observed in low-lying and intensively cultivated areas (Elbanna et al., 2023; Fadl et al., 2023). The Food and Agriculture Organization (FAO) estimates that more than 1.8 million hectares of agricultural land in Egypt are salt-affected, placing the country among the most severely impacted in Africa (FAO, 2019; Mwesige, 2025). These figures underscore the scale of the challenge, while also masking substantial spatial heterogeneity in salinity levels and underlying processes.

Over the past decade, advances in remote sensing, geospatial analysis, and field-based monitoring have significantly improved understanding of salinity dynamics in Egypt. Satellite-based analyses using Landsat 8 and Sentinel-2 imagery have enabled detailed mapping of salinity patterns and their temporal evolution across the Nile Delta and reclaimed areas (Fadl et al., 2023; Hassan & Omar, 2024). Multi-criteria approach that integrate soil properties, drainage conditions, and groundwater characteristics have further enhanced the ability to identify areas at heightened risk of salinization (Ibrahim et al., 2024). Collectively, these developments have shifted salinity research from largely descriptive assessments toward more spatially explicit and analytically robust perspectives.

At the same time, field-based studies continue to provide essential insights into the biophysical dimensions of salinity and its interaction with water management practices. Research documenting relationships between groundwater depth, soil properties, and salinity distribution highlights the importance of considering vertical as well as horizontal processes in irrigated systems (Taha & El Sayed, 2023; El-Ghannam & Wassar, 2024). Together with advances in monitoring and modelling, this body of evidence confirms that salinity in Egypt is a multifaceted challenge shaped by both natural conditions and human management choices.

1.1.2 Conceptual classification of salinization in Egypt

Salinization in Egypt results from a limited number of recurrent processes that differ in their origin, spatial scale, and temporal dynamics. While these processes often coexist within the same broad regions, their dominant drivers can be analytically distinguished. Such differentiation is essential for understanding salinity patterns, interpreting spatial variability, and avoiding misleading generalizations in subsequent impact or intervention analyses. This report classifies salinization in Egypt into four categories based on three core criteria: the origin of salts, the dominant hydrological and geochemical processes controlling salt accumulation, and the degree to which salinity patterns are structurally embedded in the soil–water system. This classification builds on established distinctions between primary and secondary salinity (FAO, 2019; Qadir &

Oweis, 2020) and further refines them to reflect the hydro-environmental diversity of Egypt (Elbanna et al., 2023; Aryal et al., 2025). The four categories are presented below in order of their relative spatial extent across Egypt's cultivated land and their relevance for national agricultural production.

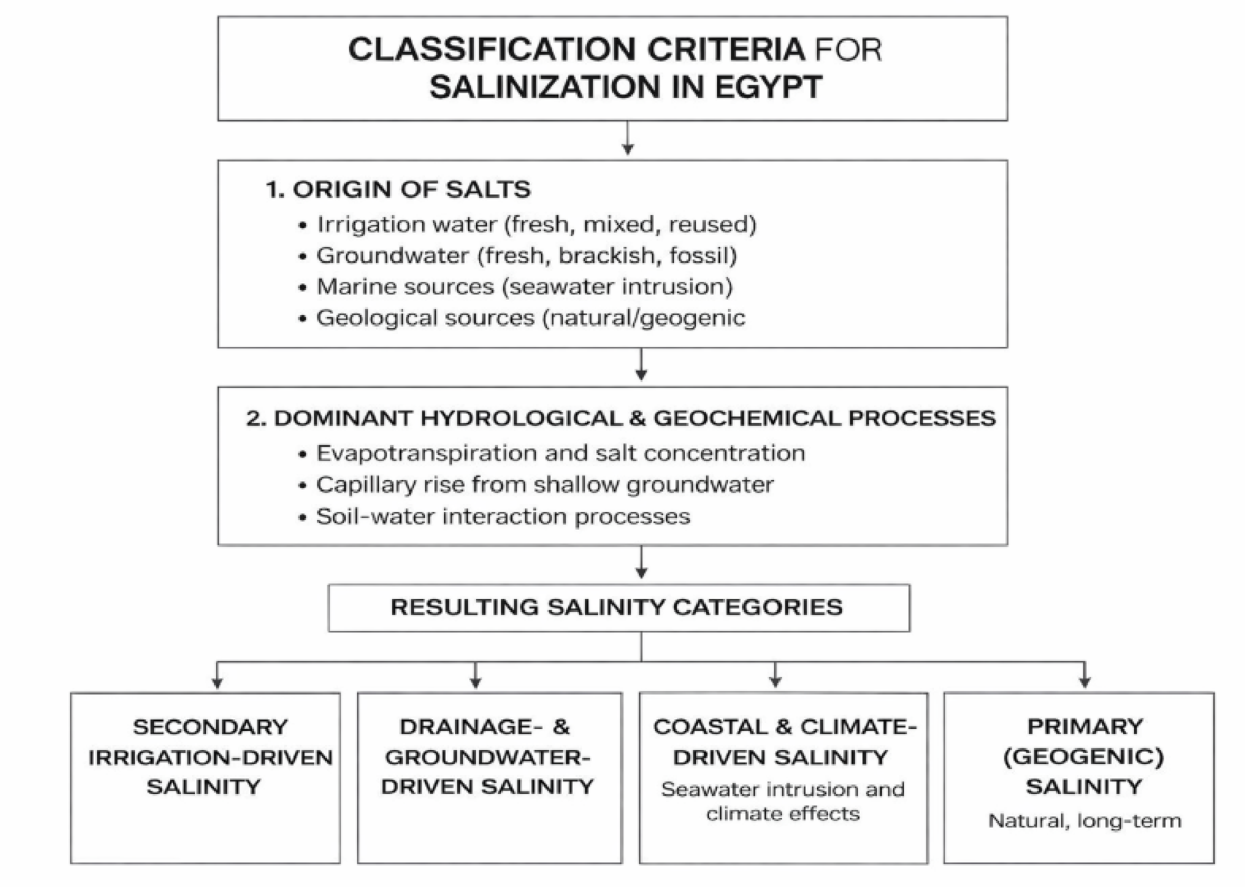

Figure 4: Diagram illustrating the criteria used to classify salinization in Egypt and the four categories derived from these criteria according to the literature

While the extent and severity of salinity in Egypt are well documented, the processes through which salinization develops vary considerably across regions and production systems;

distinguishing these underlying drivers is therefore essential for understanding salinity dynamics and for structuring effective, context-specific responses.

a) Secondary irrigation-driven salinity

Secondary irrigation-driven salinity is the most extensive form of salinization in Egypt and is directly associated with long-term irrigated agriculture under arid conditions. In this category, salts originate primarily from irrigation water itself, including Nile water and reused drainage water, and accumulate in the soil profile due to repeated application combined with high evapotranspiration and insufficient leaching.

The dominant processes include salt concentration in the root zone during crop water uptake, incomplete downward leaching of salts, and redistribution of salts through surface irrigation practices. Salinity levels typically fluctuate seasonally and are closely linked to irrigation scheduling and water management practices (Sharma, 2024; Taha & El Sayed, 2023).

Soils affected by irrigation-driven salinity generally exhibit electrical conductivity values in the range of approximately 2–6 dS/m, although localized hotspots with higher values may occur, particularly where drainage water reuse is common (FAO, 2019; Fadl et al., 2023).

In Egypt, this category predominates in large parts of the central and southern Nile Delta, including governorates such as Gharbia, Qalyubia, Menoufia, southern Dakahlia, and parts of Sharkia. Similar processes are also observed in some irrigated areas of North Sinai where mixed-quality water is used (Aryal et al., 2025).

b) Drainage and groundwater-driven salinity

Drainage and groundwater-driven salinity arises where restricted drainage capacity and shallow groundwater tables dominate salinity dynamics. In this category, salt accumulation is controlled less by the salt content of irrigation water and more by upward movement of saline groundwater into the root zone through capillary rise.

This process is particularly pronounced in flat, low-lying areas with heavy clay soils and limited natural drainage. When subsurface drainage systems are absent, poorly designed, or inadequately maintained, groundwater tables rise and salts dissolved in groundwater accumulate near the soil surface (MALR, 2009; Elbanna et al., 2023).

Typical soil salinity levels in drainage-driven systems often exceed those found in irrigation-driven salinity, commonly ranging from about 4–8 dS/m, with higher values observed in areas experiencing prolonged waterlogging (IFAD, 2025). Salinity patterns tend to be spatially persistent and less responsive to short-term changes in irrigation practices.

In Egypt, this category is most characteristic of the northern Nile Delta, particularly in Kafr El-Sheikh, northern Dakahlia, and northern Beheira. These areas are marked by shallow groundwater tables, fine-textured soils, and long-established irrigation and drainage infrastructure (FAO, 2019; El-Kased et al., 2024).

c) Coastal and climate-driven salinity

Coastal and climate-driven salinity is associated with seawater intrusion and related coastal processes. In this category, salts originate from marine sources and enter agricultural soils and aquifers through lateral or vertical movement of saline groundwater. These processes are influenced by sea-level rise, land subsidence, reduced freshwater discharge, and groundwater abstraction (FAO, 2019; Tawfik et al., 2024).

Salinity levels in coastal systems are often high and may increase over time, with soil and groundwater electrical conductivity frequently exceeding 6–10 dS/m in affected zones. Unlike inland systems, salinity dynamics here are strongly influenced by regional hydrogeological gradients and long-term climatic trends rather than by field-level water management alone (Qadir & Oweis, 2020).

In Egypt, coastal salinization is concentrated in the Mediterranean fringe of the Nile Delta, particularly north of the Rosetta and Damietta branches. Affected areas include coastal zones of

Kafr El-Sheikh, Damietta, and Beheira, where saline groundwater fronts have been observed to advance inland (FAO, 2019; Tawfik et al., 2024).

d) Primary (geogenic) salinity

Primary salinity refers to salinization that originates from natural geological and hydrochemical conditions rather than from modern irrigation activities. In these systems, salts derive from evaporitic parent materials, ancient marine sediments, or fossil saline groundwater stored in deep aquifers. Salinity is therefore structurally embedded in the soil–water system and often predates agricultural land use (Mohamed, 2016; FAO, 2019).

Salinity levels in primary salinity systems are highly variable but frequently high, with soil electrical conductivity values commonly exceeding 6–10 dS/m and, in some locations, substantially higher. Because salt sources are continuously replenished through natural processes, salinity patterns tend to be persistent over time (Mwesige, 2025).

In Egypt, primary salinity is most commonly observed in oases and desert environments, including Siwa Oasis, Wadi El-Natrun, parts of Fayoum, the Western Desert and New Valley, and sections of the Sinai Peninsula and Eastern Desert. These regions are typically characterized by closed or weakly drained basins, high evapotranspiration, and limited natural leaching (Mohamed, 2016; Elbanna et al., 2023).

1.1.3 Responses to management

The four salinization categories described above differ not only in their origin and spatial manifestation, but also in their responsiveness to management. As a result, interventions that are effective in one category may be ineffective or even counterproductive in another. Distinguishing between these categories is therefore essential for identifying technically sound and context-appropriate responses. The following section examines the types of interventions that are generally effective under each salinization category, focusing on the underlying mechanisms through which they influence salt accumulation and distribution in soils and groundwater.

a) Interventions for secondary irrigation-driven salinity

In systems dominated by irrigation-driven salinity, interventions that reduce salt loading to the soil and enhance leaching efficiency are generally most effective. Because salts are introduced primarily through irrigation water and accumulate in the root zone during evapotranspiration, management measures that improve the balance between salt inputs and outputs can substantially alter salinity dynamics (Qadir & Oweis, 2020; Sharma, 2024).

Key intervention types include improved irrigation scheduling to better match crop water demand, thereby reducing excess application and associated salt inputs. Adjusting irrigation timing and volumes can also help ensure that sufficient leaching occurs during critical periods, particularly in conjunction with seasonal rainfall or freshwater availability. Modifications to field-level water distribution, such as raised-bed cultivation or improved surface leveling, can further reduce salt accumulation by limiting waterlogging and capillary rise (Taha & El Sayed, 2023).

Soil-focused interventions, including the application of organic amendments such as compost or biochar, can improve soil structure, increase infiltration capacity, and enhance downward movement of salts beyond the root zone. Additionally, the application of (organic) mulch will reduce evaporation, which in turn avoids peaks in soil salinity and crop water demand. While such measures do not remove salts from the system, they can alter their spatial distribution and reduce salt stress in the upper soil layers (El-Ghannam & Wassar, 2024; Bruning et al., 2021). In areas where drainage water is reused, controlled reuse combined with salinity monitoring can help limit progressive salt accumulation (Tawfik et al., 2024).

b) Interventions for drainage- and groundwater-driven salinity

Where drainage and shallow groundwater are the dominant drivers of salinization, interventions must focus on restoring or enhancing the system’s capacity to remove excess water and dissolved salts. In these systems, improvements in irrigation management alone are insufficient, as salt accumulation is driven primarily by upward movement of saline groundwater rather than by surface salt inputs (FAO, 2019; IFAD, 2025).

Core intervention types include the rehabilitation of subsurface drainage networks, particularly tile drainage systems that have deteriorated due to sedimentation, clogging, or insufficient maintenance. Restoring drainage functionality lowers groundwater tables and reduces capillary rise, thereby limiting the upward transport of salts into the root zone (MALR, 2009; Elbanna et al., 2023).

Controlled drainage systems, which allow operators to adjust outflow levels seasonally, can further optimize the balance between water conservation and salt removal. Complementary field-level measures, such as improving soil structure through organic amendments, can enhance the effectiveness of drainage by increasing permeability. However, the success of such interventions depends on sustained operation and maintenance, as well as coordination across farms sharing drainage infrastructure (IFAD, 2025).

c) Interventions for coastal and climate-driven salinity

In coastal and climate-driven salinity systems, interventions must address processes that operate at scales beyond individual fields. Because salinity originates from marine sources and is influenced by regional groundwater dynamics, effective management requires measures that limit saline intrusion and reduce exposure of agricultural soils to saline water (FAO, 2019; Tawfik et al., 2024).

Relevant intervention types include regulation of groundwater abstraction to reduce landward hydraulic gradients that promote seawater intrusion. Where feasible, managing the balance between surface water and groundwater use can slow the inland advance of saline fronts. In some contexts, blending freshwater with brackish water may reduce salinity levels in irrigation supplies, although this approach does not eliminate the underlying source of salinity (Qadir & Oweis, 2020).

Land-use adjustments also play an important role in coastal zones. Allocating salt-sensitive crops to lower-risk areas and encouraging more salt-tolerant cropping systems in high-risk zones can reduce the vulnerability of agricultural production to progressive salinization. Because climate-driven processes are expected to intensify, such measures are often framed as long-term adaptation rather than short-term remediation (FAO, 2019).

Finally, land management practices may also be effective in these regions, such as the construction of dykes, living shorelines or other nature-based solutions. We will elaborate on this in the policy section below.

d) Interventions for primary (geogenic) salinity

In primary salinity systems, interventions aimed at removing salt from the soil are generally of limited effectiveness, as salt sources are continuously replenished through natural geological and hydrochemical processes. As a result, management strategies in these systems focus on adaptation to persistent salinity conditions rather than on attempts at reclamation (Qadir & Oweis, 2020; Mwesige, 2025).

Intervention types commonly applied in such contexts include the cultivation of salt-tolerant crops and halophytic species that can maintain productivity under high salinity levels. The development of saline ecosystems may also be considered, such as inland salt marshes that can perhaps sustain rich ecosystems with iconic species such as flamingos.

Adjustments to cropping systems, such as shifting from intensive annual crops to perennial or mixed systems, can also improve system stability under saline conditions. Organic amendments may enhance soil physical properties and water-holding capacity, but they do not fundamentally alter salinity levels and are therefore best viewed as productivity-supporting rather than salinity-reducing measures (Mohamed, 2016). Because primary salinity is structurally embedded, interventions are most effective when they align agricultural land use with the long-term salinity regime rather than attempting to reverse it.

Table 1 summarizes the relative suitability of major salinity-management interventions across the four salinization categories. Symbols indicate whether an intervention constitutes a core response, a complementary measure, or is generally unsuitable given the dominant salinity mechanisms. Context-dependent interventions require careful design and monitoring to avoid unintended salinity accumulation.

Table 1: Suitability of salinity-management intervention types by salinization category in Egypt

Intervention type	**Irrigation-driven**	**Drainage-driven**	**Coastal & climate-driven**	**Primary (geogenic)**
Improved irrigation scheduling	✓✓	△	×	×
Field-level water management (e.g., raised beds, leveling)	✓	△	×	×
Organic soil amendments (compost, biochar)	✓	✓	△	△
Subsurface drainage rehabilitation	△	✓✓	△	×
Controlled drainage systems	✓	✓	×	×
Drainage-water reuse	△*	△*	×	×
Freshwater–brackish water blending	△	△	✓	△
Salt-tolerant crops / halophytes	△	△	✓	✓✓

Intervention type	Irrigation-driven	Drainage-driven	Coastal & climate-driven	Primary (geogenic)
Land-use adjustment / system extensification	╳	△	✓✓	✓✓

Legend

✓✓ = highly suitable / core intervention

✓ = suitable

△ = context-dependent / complementary

╳ = generally not suitable

* Requires careful salinity monitoring to avoid progressive salt accumulation.

1.1.4 System-scale adaptation and enabling measures in areas affected by primary salinization

In areas affected by coastal and climate-driven salinity, long-term changes in sea level, land subsidence, and hydrological gradients increasingly shape salinity dynamics. While field-level and irrigation-system interventions remain important, they are insufficient on their own to address salinization processes that operate at coastal and basin scales. In this context, coastal protection measures and nature-based solutions can play a complementary role as part of a broader adaptation strategy. These two categories of salinization are most similar to each other in our four-way classification when it comes to effective intervention measures.

Hard coastal infrastructure, such as dykes, levees, and sea walls, can reduce the frequency and extent of direct marine inundation during storm surges and extreme events. By limiting episodic saltwater flooding of low-lying agricultural areas and drainage outlets, such structures can help prevent sudden increases in soil and surface-water salinity. However, these measures do not directly address subsurface seawater intrusion into coastal aquifers and therefore cannot, on their own, prevent the gradual inland movement of saline groundwater (FAO, 2019; Qadir & Oweis, 2020).

Nature-based solutions, including the restoration or construction of coastal wetlands and buffer zones, offer additional pathways to moderate salinity dynamics. Wetlands can function as hydrological and ecological buffers by slowing saline water movement, promoting mixing and dilution of saline and freshwater flows, attenuating wave energy, and supporting sediment deposition that may partially offset land subsidence. In delta systems worldwide, such measures are increasingly recognized as cost-effective complements to hard infrastructure under climate change scenarios (FAO, 2019; IPCC, 2022).

In the Egyptian context, the application of nature-based solutions must be adapted to local ecological conditions. True mangrove systems are not naturally suited to the Mediterranean environment of the Nile Delta. However, functionally equivalent systems based on salt-tolerant wetland vegetation, reeds, and halophytic species may provide similar buffering functions. Such systems can also serve as transitional land-use zones between marine and agricultural areas, particularly where conventional cropping is becoming increasingly vulnerable to salinity.

Importantly, both hard and nature-based coastal measures should be understood as preventive and enabling strategies rather than as direct salinity-control interventions. Their effectiveness depends on integration with groundwater management, land-use planning, and agricultural adaptation measures. When implemented in isolation, they risk creating a false sense of protection without addressing underlying salinity drivers (Tawfik et al., 2024).

1.1.5 Protected agriculture as a strategic response to salinity and water scarcity

In the context of increasing salinization, water scarcity, and climate variability, protected agriculture represents an important complementary pathway for strengthening Egypt’s food security. While protected cultivation systems are not a direct salinity-management intervention, they offer a means to decouple crop production from degraded soil and water conditions and to reduce exposure to salinity-related risks. As such, protected agriculture can play a strategic role within a differentiated adaptation framework, particularly where conventional open-field agriculture becomes increasingly constrained.

Protected agriculture encompasses a spectrum of production systems, ranging from low-technology plastic tunnels and shade houses to high-technology greenhouses equipped with controlled irrigation, fertigation, and climate regulation. Across this spectrum, a common feature is the ability to tightly manage water inputs, soil or substrate conditions, and microclimate, thereby reducing salt accumulation and crop exposure to saline stress (FAO, 2013; Qadir & Oweis, 2020).

One of the principal advantages of protected agriculture in saline environments is its potential to significantly improve water-use efficiency. Drip irrigation and fertigation systems commonly used in greenhouses allow precise application of water and nutrients, reducing the total volume of irrigation water required and limiting salt loading to the root zone. In substrate-based or soilless systems, salt accumulation in soils can be avoided altogether, as salinity is managed through controlled nutrient solutions and periodic flushing (FAO, 2019; van Halsema & El Gendy, 2024).

From a salinity perspective, protected agriculture is particularly relevant in areas affected by irrigation-driven and drainage-driven salinity, where soil degradation constrains yields but access to irrigation water and infrastructure remains relatively good. In such contexts, shifting part of production to protected systems can reduce pressure on saline soils while maintaining or increasing output per unit of water. Protected cultivation may also be relevant in coastal and climate-driven salinity zones, where increasing salinity and climatic extremes raise the risk profile of open-field horticulture (Tawfik et al., 2024).

At the national scale, protected agriculture contributes to food security not primarily by replacing staple crop production, but by stabilizing and intensifying the production of high-value and nutritionally important crops, such as vegetables. By increasing productivity per unit area and per unit water, protected systems can offset losses in open-field systems affected by salinity, while also generating income opportunities that support rural livelihoods (FAO, 2013; Abdel-Rahman & Belal, 2023).

However, high-technology greenhouse systems require substantial capital investment, reliable energy supply, technical expertise, and effective management of drainage and waste nutrient solutions to prevent secondary salinization outside the protected structures. Lower-technology systems, while more accessible, offer more limited control over salinity and climate and may still be vulnerable if poorly managed (Qadir & Oweis, 2020).

For these reasons, protected agriculture should be viewed as part of a broader portfolio of adaptation strategies rather than as a universal solution. Its strategic value lies in its capacity to concentrate production where environmental control is feasible, to reduce dependence on saline soils for sensitive crops, and to complement open-field agriculture in regions where salinity and water scarcity are expected to intensify under climate change scenarios.

A special mention here deserves the use of low-cost open field hydroponics systems. They also de-couple the use of (degraded) soil and food production. Additionally, they have been and are being used successfully in Egypt and outside for crop production. These types of systems may offer a special kind of solution under the same conditions as protected agriculture.

1.1.6 Policy implications of differentiated salinity management in Egypt

The Netherlands' historical and contemporary experience in integrated water management, salinity control, and adaptive land use offers a complementary perspective that may contribute to mutual learning. The suggestions presented in this section are therefore intended as inputs to an ongoing dialogue, grounded in Egyptian priorities and institutions, and aimed at identifying opportunities for collaboration, adaptation, and co-development rather than one-directional knowledge transfer.

The classification of salinization in Egypt into four analytically distinct categories has direct implications for policy design, institutional coordination, and investment prioritization. Because these categories differ fundamentally in their dominant drivers, spatial scales, and responsiveness to management, effective salinity policy cannot rely on uniform instruments or generic technical solutions. Instead, policy must enable differentiated responses that align interventions with underlying salinity mechanisms, while remaining embedded in Egypt's institutional and governance context.

a) From region-based to mechanism-based policy design

Historically, salinity management in Egypt has been addressed largely through regionally defined programs, with a strong emphasis on large-scale drainage infrastructure in the Nile Delta and water-use efficiency in reclaimed lands (MALR, 2009; FAO, 2019). These approaches have delivered important benefits, particularly through the extensive national drainage network managed by the Egyptian Public Authority for Drainage Projects. At the same time, experience from recent projects indicates that region-based approaches alone do not fully capture the diversity of salinity mechanisms operating within and across regions.

By distinguishing between irrigation-driven, drainage-driven, coastal, and primary salinity systems, policymakers and implementing agencies can more clearly assess where remediation is technically feasible and where adaptation is the more appropriate objective (Qadir & Oweis, 2020; Aryal et al., 2025). This distinction is particularly relevant for national planning processes coordinated by the Ministry of Water Resources and Irrigation and the Ministry of Agriculture and Land Reclamation, both of which operate across multiple agro-hydrological contexts.

b) Institutional alignment with salinity categories

Different salinity categories imply different institutional entry points and leadership roles within Egypt's existing governance architecture.

In areas dominated by secondary irrigation-driven salinity, policy action aligns closely with the mandates of the Ministry of Agriculture and Land Reclamation and its affiliated research and extension bodies, including the Agricultural Research Center and its soil, water, and crop research institutes. These organizations are well positioned to support farmer-level management improvements through extension services, demonstration plots, and applied research, particularly in the central and southern Nile Delta.

For drainage- and groundwater-driven salinity, the Egyptian Public Authority for Drainage Projects plays a central role, given its responsibility for the planning, operation, and maintenance of subsurface drainage infrastructure. Effective policy in these systems also requires close coordination with the Ministry of Water Resources and Irrigation at both national and governorate levels, as well as engagement with water-user associations that operate and maintain local infrastructure. Strengthening these linkages has been identified as a priority in multiple IFAD evaluations (Independent Office of Evaluation of IFAD, 2025).

Coastal and climate-driven salinity systems necessitate broader institutional engagement. In addition to the Ministry of Water Resources and Irrigation and the Ministry of Agriculture and Land Reclamation, relevant actors include agencies responsible for groundwater regulation, coastal-zone management, and climate adaptation planning. Coordination with governorate-level authorities in coastal areas, as well as with national bodies involved in climate policy and spatial planning, is essential to address salinity risks that extend beyond the agricultural sector (FAO, 2019; Tawfik et al., 2024).

In primary (geogenic) salinity systems, such as oases and desert environments, policy engagement often intersects with land-reclamation authorities, local administrations, and research institutions specializing in arid-land agriculture and natural resource management. In these contexts, Egyptian universities and research centers with long-standing experience in desert agriculture play a key role in guiding land-use decisions that align with persistent salinity regimes (Mohamed, 2016; Mwesige, 2025).

c) Role of data, monitoring, and knowledge institutions

Across all salinity categories, the effectiveness of differentiated salinity management depends on the availability of reliable, harmonized, and regularly updated data on soil, groundwater, drainage networks, and crop performance. As highlighted in recent research and project evaluations, Egypt’s current monitoring landscape is highly fragmented, with soil EC measurements, groundwater salinity data, drainage-flow assessments, and remote-sensing products scattered across multiple agencies including MWRI, MALR, EPADP, ARC, universities, and donor-supported projects. Because each institution collects data for its own mandates, the resulting datasets differ in measurement frequency, spatial coverage, calibration methods, and accessibility, which limits their usefulness for coordinated planning. Many interviewees noted that decision-makers are often forced to rely on outdated datasets or localized monitoring efforts, making it difficult to identify emerging hotspots or evaluate the effectiveness of interventions.

This fragmentation stands in contrast with the substantial scientific progress made in recent years. The literature referenced in the review including geospatial salinity maps from Sentinel-2 and Landsat 8, multi-criteria soil-quality indices, and groundwater–seawater intrusion models—demonstrates that Egypt possesses strong analytical capacity, but lacks the institutional architecture to ensure that these tools inform day-to-day water and land-use decisions. Several studies emphasized the need for standardized EC measurement protocols, improved field calibration points for satellite products, and integrated groundwater monitoring capable of tracking shallow water-table fluctuations that strongly influence salinity.

Given these gaps, there is broad consensus across the research and policy communities on the need to establish a National Salinity Observatory a centralized institutional mechanism that consolidates geospatial datasets, field-based EC measurements, groundwater salinity readings, drainage-network performance indicators, and socio-economic data into a single, interoperable platform. Such an observatory would allow ministries, governorate-level agencies, and research institutions to share data, validate findings, and coordinate interventions. It would also support predictive planning, enabling Egypt to combine hydrological models, seawater intrusion forecasts, remote-sensing analytics, and on-farm diagnostics to guide adaptive irrigation scheduling, drainage rehabilitation, and investment prioritization.

The role of knowledge institutions is essential for creating a continuous feedback loop between research, policy, and field implementation. Research centers and universities generate vital insights into soil chemistry, salinity processes, and irrigation–drainage interactions; however, these findings often remain undistributed and do not reach extension systems or policymakers in a proper time. Strengthening the linkages between knowledge institutions and the national monitoring system would ensure that scientific evidence directly informs national planning, regional intervention packages, and local advisory services. This alignment is necessary for Egypt to transition from fragmented, reactive responses to a coherent, evidence-based salinity-management framework capable of supporting long-term climate resilience.

d) Scaling collaboration and mutual learning

Recent initiatives such as the Agricultural Sustainability and Adaptation Programme, the Dutch-funded Pro-Sal-HYDRO, DESALT and Rootgrow projects, and IFAD-supported SAIL and PRIDE programs demonstrate Egypt's growing capacity for evidence-based salinity management and institutional learning (Mohamed & Wassar, 2022; Independent Office of Evaluation of IFAD, 2025). These initiatives illustrate that effective salinity management emerges from sustained interaction between research, policy, and practice.

Within this context, international collaboration, including with Dutch public and private actors, can be most effective when framed as a process of mutual learning. Rather than transferring predefined solutions, collaborative programs can focus on joint problem definition, pilot testing under Egyptian conditions, and iterative adaptation.

Egypt needs a structured, multi-level scaling strategy that promotes both horizontal and vertical learning. Horizontal scaling involves replicating proven intervention packages such as controlled drainage, compost/biochar amendments, salinity-tolerant varieties, and irrigation-scheduling tools across regions that share similar salinity drivers, whether seawater intrusion in the northern Delta, evapoconcentration in Fayoum, or brackish groundwater in desert reclamation zones. Vertical scaling requires embedding these practices into national strategies, planning tools, and investment frameworks ensuring that lessons learned feed directly into policy cycles and funding mechanisms.

Equally essential is the creation of institutionalized platforms for mutual learning, where government agencies, research centers, local experts, private firms, and farmer groups regularly exchange insights into salinity dynamics, intervention performance, and adoption barriers. Farmer-training hubs, and shared monitoring platforms offer practical entry points for facilitating these learning loops. Structured learning partnerships between Egyptian and Dutch institutions leveraging Dutch experience in saline agriculture, controlled drainage, and data-driven water governance can further accelerate knowledge transfer and contextual adaptation. Ultimately, scaling salinity management in Egypt requires not only technical solutions, but also continuous learning, coordinated implementation, and adaptation to diverse local contexts.

e) Institutional engagement for coastal salinity adaptation

The design and implementation of coastal protection and nature-based adaptation measures require coordinated engagement across multiple institutions, reflecting the cross-sectoral nature of coastal salinity dynamics. Unlike irrigation- or drainage-driven salinity, which can often be addressed within the agricultural and water-management sectors, coastal salinity intersects with coastal-zone governance, groundwater regulation, spatial planning, and climate adaptation.

Within Egypt’s institutional landscape, the Ministry of Water Resources and Irrigation plays a central role due to its mandate over surface water allocation, groundwater management, and coastal protection infrastructure. Its technical agencies and regional directorates are key actors in assessing hydrological impacts of sea-level rise and saline intrusion and in integrating coastal measures with broader water-resources planning. The Ministry of Agriculture and Land Reclamation has an important complementary role, particularly in aligning coastal adaptation strategies with agricultural land-use planning, crop selection, and extension services in vulnerable coastal governorates.

At the governorate level, coastal administrations in areas such as Kafr El-Sheikh, Damietta, and Beheira are important for translating national strategies into locally appropriate land-use decisions. These authorities are often best positioned to identify zones where agriculture can be sustained, where adaptive cropping systems are viable, and where gradual land-use transitions may be required. Research and knowledge institutions, including Egyptian universities and national research centers with expertise in coastal geomorphology, wetland ecology, and climate adaptation, play a key role in designing context-appropriate solutions.

Finally, international cooperation and development partners can contribute by supporting pilot projects, applied research, and knowledge exchange. In this context, collaboration with Dutch institutions and businesses can be framed around shared delta challenges and joint learning on integrated coastal management, combining technical expertise with Egyptian institutional leadership. However, considerable experience on projects that involve international collaboration among different types of institutes already exists, and we believe it is time to take the lessons learned in these projects to the next level.

1.1.7 Projected climate change impacts on salinity and freshwater availability in Egypt

Climate change is expected to significantly intensify existing salinization processes and pressures on freshwater availability in Egypt, particularly in the Nile Delta and other irrigated lowland areas. Rather than introducing fundamentally new mechanisms, climate change is projected to amplify current interactions between arid climatic conditions, intensive irrigation practices, limited drainage capacity, and widespread water reuse. As a result, salinity risks that are already present are expected to become more severe, spatially extensive, and difficult to manage.

Sea-level rise represents one of the most critical climate-related drivers of future salinization in Egypt. Scenario analyses indicate that rising sea levels will accelerate saltwater intrusion into coastal aquifers of the Nile Delta, leading to higher groundwater salinity and increased upward salt fluxes into the root zone (IPDC Secretariat, 2025). Given the low elevation of large parts of the northern Delta and the already shallow groundwater tables, even moderate sea-level rise is expected to expand the spatial extent of salinity-affected soils and reduce the availability of freshwater suitable for irrigation.

In parallel with sea-level rise, higher temperatures associated with climate change will substantially increase evapotranspiration rates. This will reduce effective freshwater availability per hectare and concentrate salts in both irrigation water and soils. Even under scenarios in which total Nile inflows remain relatively stable, increased evaporative demand is expected to accelerate secondary salinization processes (Qadir & Oweis, 2020). These effects are particularly pronounced in areas where natural leaching is constrained by shallow groundwater tables, insufficient drainage capacity, and heavy clay soils.

1.1.8 Economic benefits of salinity adaptation – evidence from the literature

The table below presents selected literature-based evidence on the economic benefits associated with salinity adaptation measures. It provides indicative quantitative findings on yield improvements, income gains, and risk reduction linked to interventions such as drainage, irrigation management, soil improvement, and salt-tolerant crops.

Measure	**Demonstrated economic benefit**	**Quantitative indication**	**Reference**
Large-scale subsurface drainage	Structural yield increase and income growth	Groundwater table lowered by 0.5–1.0 m; yield increases of 15–30% for cotton, wheat and rice	Abdel-Dayem (1987); FAO (2019)
Drainage rehabilitation and maintenance	Preservation of earlier investments and income stability	Prevents yield losses of 10–20% caused by failing drainage systems	IFAD IOE (2025); MALR (2009)

Measure	**Demonstrated economic benefit**	**Quantitative indication**	**Reference**
Salt-tolerant crops (general)	Reduced yield losses and more stable farm income	20–40% lower yield losses under saline conditions compared to sensitive crops	Aryal et al. (2025)
Salt-tolerant potato variety combined with compost application	Substantial increase in net financial returns under saline conditions	Up to ~88% higher net economic return compared to a salt-sensitive variety, after accounting for additional compost costs	Bruning et al. (2021)
Controlled irrigation combined with drainage	Increased water productivity and yield stability	15–20% reduction in water use while maintaining approximately 80% of potential yield	El-Ghannam & Wassar (2024)
Improved irrigation management	Reduced yield variability and economic risk	Yield variability reduced by 10–30%	Qadir & Oweis (2020)
Soil improvement (compost, organic matter)	Higher yields and lower production costs	Yield increases of 10–20%; reduced need for leaching and replanting	El-Kased et al. (2024); Sharma (2024)

Measure	Demonstrated economic benefit	Quantitative indication	Reference
Integrated adaptation programs (IFAD / ASAP)	Increased farm income and resilience	Net farm income 15–35% higher in participating project areas	Mohamed & Wassar (2022); IFAD IOE (2025)
Avoiding uncontrolled reuse of saline drainage water	Prevention of system-level economic losses	Avoids downstream yield losses of >10%	Tawfik et al. (2024)

1.2 Stakeholder consultations (interviews/ Focus Group Discussions)

The development of this Roadmap was informed by a series of semi-structured interviews and technical discussions held between October and November 2025. These engagements were designed to capture a wide spectrum of expertise, operational experiences, and institutional perspectives relevant to salinity management in Egypt. To ensure confidentiality and maintain unbiased analysis, individual participants are not named; instead, their contributions are synthesized thematically.

A diverse set of stakeholders contributed to this process, including senior government officials, policy advisors, researchers, academics, private-sector actors, agribusinesses, and local water-management practitioners. Their collective insights help contextualize the findings from the literature review, validate technical claims, and highlight converging priorities across multiple domains.

To provide a clear and professional synthesis, stakeholder perspectives have been organized into four thematic pillars, each reflecting a distinct dimension of Egypt's salinity challenge.

1.2.1 Governance, Policy Frameworks, and Salinity

This pillar consolidates insights from national government representatives and policy advisors involved in irrigation management, water resources, agricultural planning, and drainage governance. Their perspectives focus on institutional mandates, regulatory frameworks, modernization initiatives, and the policy mechanisms required to strengthen Egypt's salinity management system.

1.2.2 Scientific Research and Knowledge Innovation

This pillar reflects contributions from leading academic institutions and national research centers specializing in saline agriculture, hydrology, agronomy, soil sciences, and agricultural engineering. These experts provided evidence-based insights into salinity dynamics, region-specific intervention packages, and the scientific considerations needed to support differentiated solutions.

1.2.3 Private Sector Engagement and Market Viability

This sub-section captures the views of agribusinesses, Dutch–Egyptian seed companies, technology providers, water-services firms, and desert-land developers. Their inputs highlight commercial feasibility, operational constraints, investment needs, innovation pathways, and market-driven opportunities for scaling salinity-smart agriculture.

1.2.4 Local Management and Water User Perspectives

This pillar synthesizes insights from regional irrigation specialists, Water User Associations, and on-ground technical practitioners. Their contributions focus on field-level realities, drainage system performance, farmer behavior, and the operational challenges shaping salinity outcomes.

To complement the thematic synthesis presented above, the following anonymized interview summaries provide deeper technical and institutional insights from individual experts consulted during the roadmap's development. To respect privacy and confidentiality, the names of individual interviewees have been removed. However, their affiliated organizations or stakeholder groups are referenced to provide context and ensure the relevance of the insights presented.

Expert 1: Senior Representative from the Ministry of Water Resources and Irrigation

Expert 1 emphasized that the salinity problem in Egypt cannot be understood without acknowledging the rapidly transforming water status of the Nile Delta. They explained that rising salinity levels are closely linked to the intensification of drainage water reuse, the inefficiency of existing conveyance systems, and the growing need for localized treatment facilities capable of handling increasingly saline flows. According to the expert, Egypt urgently requires additional water-treatment stations, particularly in the northern Delta, to reduce the cumulative salt load that currently flows untreated into irrigation canals or, alternatively, is discharged into the sea. Rather than allowing valuable drainage water to be lost, they suggest that it should be treated, blended, and reintegrated into the agricultural supply, thereby extending the availability of limited freshwater resources while moderating salinity risks.

The expert linked these technical issues to a broader institutional shift within the Ministry of Water Resources and Irrigation, describing the current phase as part of a "second generation of irrigation (irrigation 2.0)", where modernization goes far beyond drip systems and instead incorporates digital governance tools, farmer-level regulation, and institutional accountability. They highlighted initiatives such as the "Know Your Turn" application, which seeks to improve water distribution transparency, and renewed efforts to strengthen Water User Associations to support both irrigation scheduling and drainage maintenance. They emphasized that governance reforms of this type are essential to prevent salinity from worsening under modernization programs that, if poorly coordinated, can inadvertently increase root zone salt accumulation by reducing leaching.

Expert 1 also stressed that while national strategies such as the National Water Resources Plan (NWRP) provide a strong conceptual basis for integrated salinity management, actual implementation remains unclear due to overlapping implantation between ministries, limited enforcement mechanisms, and fragmented monitoring arrangements. The expert warned that data inconsistencies and the absence of a unified national salinity monitoring framework severely constrain evidence-based planning. The expert recommended establishing a centralized data and monitoring platform capable of harmonizing groundwater EC measurements, drainage water quality records, and treatment-plant performance. Such a platform, in their view, would allow for better targeting of interventions, more accurate leaching recommendations, and improved alignment between water-allocation decisions and salinity-risk assessments.

Finally, expert 1 argued that salinity management should be explicitly connected to investment strategy, noting that advanced technologies, including desalination, blending systems, and protected agriculture are costly and must be prioritized for areas where returns justify their use. They advised that high-value crops, controlled-environment systems, and export-oriented production clusters are most suited to absorb the financial and operational costs associated with treating and managing saline water. They concluded that without this economic prospective, technical solutions may fail to be scaled up, and salinity will continue to impact productivity in both the Nile Delta and new agricultural expansion zones.

Expert 2: Senior Representative from the Agricultural Policy Sector, Ministry of Agriculture

Expert 2 highlighted that Egypt’s agricultural strategies, including SADS 2030, contain strong references to modern irrigation, drainage rehabilitation, and the adoption of salt tolerant crops, yet the main challenge lies in translating these plans into sustained field level implementation. The expert argued that the weakening of agricultural extension services has created a gap between policy and practice, reducing farmers’ capacity to adopt improved salinity management techniques. The expert noted that rice cultivation in appropriate northern Delta zones remains an effective leaching mechanism that helps counter seawater intrusion. The expert concluded that more robust regulatory enforcement, coupled with practical tools such as regionally tailored leaching guidance, is needed to operationalize national strategies on a scale.

Expert 3: Senior Research Specialist in Saline Agriculture at the Egyptian Center of Excellence for Saline Agriculture

Expert 3, representing the national research community specialized in saline agriculture, offered a comprehensive and technically detailed perspective on the processes shaping salinity across Egypt's landscapes and the types of interventions most likely to succeed. They emphasized that salinity in Egypt is not a uniform issue but rather a complex interaction of hydrological, soil-chemical, and management-related factors that vary significantly across regions. In their assessment, the most common mistake in current mitigation efforts is the application of isolated or generic practices rather than regionally tailored, research-based intervention packages. They noted that decades of field experimentation, supported by applied research programs in the Nile Delta, Fayoum Depression, Western Desert, and Sinai; demonstrate that meaningful salinity reduction occurs only when integrated practice bundles are applied in combination. These bundles typically include soil amendments such as gypsum, compost, and biochar, paired with controlled drainage systems, planned leaching cycles, optimized irrigation scheduling, and the introduction of salt-tolerant crop varieties adapted to local climatic and hydrological conditions.

The expert elaborated that the scientific rationale behind these integrated packages lies in how different components interact to correct soil structure, modify exchangeable cation balances, and improve water infiltration. For instance, gypsum mobilizes sodium ions and improves soil permeability, while compost and biochar enhance soil organic matter, increase cation-exchange capacity, and strengthen microbial activity; all of which are essential for sustaining root-zone function under saline stress. Controlled drainage, when properly managed, prevents waterlogging while maintaining favorable groundwater depths, thereby reducing capillary salt rise. According to the expert, the effectiveness of these interventions diminishes significantly when applied piecemeal, which is why farmers often report limited success when using a single amendment without complementary practices.

A major theme in their insights was the critical role of monitoring, which they described as one of the most neglected dimensions of salinity management in Egypt. The expert noted that salinity dynamics can shift within a single season due to changes in irrigation water sources, leaching efficiency, and drainage performance. As such, they argued that routine EC monitoring, ideally weekly or at minimum seasonally; is indispensable for diagnosing problems early and adjusting practices before yield losses occur. The expert expressed concern that many existing soil and groundwater salinity datasets are outdated, fragmented, or inaccessible, making it difficult for researchers, policymakers, and extension officers to establish accurate baselines for decision-making. In their view, any effective national strategy must include a coordinated monitoring system that aggregates soil EC, groundwater EC, drainage-water quality, and crop performance indicators in a standardized manner. They supported the establishment of a centralized monitoring entity or a “National Salinity Observatory” that harmonizes datasets from research institutes, ministries, and private-sector actors.

Furthermore, expert 3 stressed the importance of recognizing regional differentiation in designing interventions. They explained that in the Northern Nile Delta, shallow groundwater and seawater intrusion require a heavy emphasis on controlled drainage, salt-tolerant crop rotations, and large-scale leaching events. In Fayoum, by contrast, the closed-basin nature of the depression means that salts accumulate through evapoconcentration, requiring interventions centered on water reuse management, internal drainage improvement, and careful scheduling of leaching to avoid waterlogging. In desert reclamation areas, where brackish groundwater is common and drainage is often underdeveloped, the expert reiterated that success depends on combining amended soils with precise irrigation layouts, moisture-retention strategies, and engineering solutions that enhance water percolation and prevent salt accumulation in the root zone.

The expert also highlighted a structural challenge: the weak link between research and field implementation. Although Egypt possesses significant research capacity and decades of experimental evidence on salinity management, the expert observed that much of this knowledge remains siloed within academic or research institutions, with limited transfer to farmers or local authorities. They identified institutional fragmentation, inconsistent coordination between ministries, and the decline of extension services as the main reasons why research findings often fail to inform practice at scale. They argued that multi-institutional collaboration, especially between the Ministry of Water Resources and Irrigation, the Ministry of Agriculture, national research institutes, and private-sector actors; is essential for designing and disseminating practical, region-specific packages that farmers can adopt. Demonstration farms, farmer-training hubs, and shared monitoring platforms were identified as mechanisms capable of bridging this gap.

Finally, the expert emphasized that addressing salinity is not only a technical challenge but also a socio-economic one. They noted that farmers are often reluctant to adopt research recommended practices unless there is clear economic justification and visible improvement within one or two growing seasons. They cautioned that interventions must be both scientifically valid and cost effective, and that scaling requires financial incentives, reliable input supply chains, and supportive policy frameworks. Without these enabling conditions, even the best-validated saline-management techniques risk remaining confined to pilot projects rather than becoming widespread solutions.

Expert 4: Professor of Horticulture at the Faculty of Agriculture, Kafr Elsheikh University

Expert 4 described the spatial distribution of salinity across the Nile Delta, noting that areas such as Kafr El Sheikh, Beheira, and Dakahlia face severe challenges where drainage systems underperform and shallow groundwater rises into the root zone. They observed that although irrigation modernization is often promoted as a solution, the adoption of drip or sprinkler systems without planned leaching can accelerate salt accumulation in the root zone. The expert strongly recommended the physical separation of irrigation and drainage canals to prevent cross contamination and argued that controlled drainage retrofits represent a technically sound and scalable option for Delta areas experiencing chronic salinity and waterlogging.

Expert 5: Professor of Agronomy and Plant Protection, Faculty of Agriculture, Ain Shams University

Expert 5 focused on the agronomic dimensions of salinity management, noting that inappropriate land preparation practices, particularly deep plowing, can worsen salinity by bringing salt laden soil layers to the surface. They emphasized the importance of enhancing soil health through organic matter, especially compost and biochar; and correcting soil pH to improve nutrient uptake under saline conditions. They also recommended raised bed planting systems, which improve infiltration and reduce capillary salt rise in heavy clay soils. According to this expert, strategic crop diversification using salt tolerant varieties and deep rooted species can support long-term soil rehabilitation while maintaining economically viable agricultural livelihoods.

Expert 6: Founder of a Private Laboratory for Soil and Water Diagnostics

Expert 6 provided insights from a diagnostic and advisory service perspective, noting that many farmers unknowingly exacerbate salinity by irrigating with mixed or saline water sources, often misattributing the resulting symptoms to nutrient deficiencies. They emphasized that improved access to soil and water diagnostics, combined with EC-based irrigation scheduling, can significantly reduce mismanagement. The expert stressed that adoption barriers are strongly tied to farmer trust and financial constraints, and that successful interventions must therefore demonstrate clear yield improvements and measurable reductions in soil salinity. They highlighted the importance of practical, low-cost pretreatment options for brackish water, especially within protected agriculture systems.

Expert 7: Agricultural Engineering Researcher from an Agricultural Research Centre (ARC)

Expert 7 highlighted that many subsurface drainage networks in both old and new lands have deteriorated or been poorly maintained, severely limiting their effectiveness. However, the drainage system is inefficient, the government has recently developed the drainage system in many areas. They explained that even relatively simple and low-cost drainage systems can significantly reduce salinity risks when installed and maintained properly. However, the lack of clarity around responsibility for operation and maintenance remains a persistent bottleneck. The expert argued that empowering Water User Associations and establishing community based maintenance units could enhance long-term performance and reduce the need for repeated rehabilitation of the same infrastructure.

Expert 8: Remote-Sensing and Geospatial Analysis Specialist from a Dutch Technology company

Expert 8 described the growing role of satellite-based monitoring in supporting salinity management, explaining that while remote sensing cannot directly detect soil salinity, it can reliably identify evapotranspiration, yield gaps, and moisture stress patterns associated with salinity buildup. The expert emphasized that all remote-sensing outputs must be complemented by on ground EC measurements for calibration and accuracy. The expert supports the idea that combines satellite data with field diagnostics, enabling better planning of leaching events, irrigation scheduling, and drainage interventions. Their perspective aligned with the broader call for a national salinity monitoring system that integrates hydrological, geospatial, and agronomic datasets.

Expert 9: Senior Representative from a Large-Scale Desert Land Reclamation Agribusiness

Expert 9 discussed salinity challenges from the viewpoint of large-scale investors operating in reclaimed desert lands. They highlighted that brackish groundwater, high evaporation, and weak drainage infrastructure significantly constrain productivity and raise operational risks. They noted that protected agriculture, water blending strategies, and the use of salt tolerant crops are becoming increasingly central to sustainable production models. The expert stressed the importance of clearer leaching requirements, predictable regulatory environments, and co financing mechanisms that can support the installation of drainage infrastructure and water quality systems that are otherwise cost prohibitive for individual investors.

1.2.5 Main Takeaways from Stakeholders Interviews

The interviews reveal a set of messages across government representatives, research institutions, academia, and private agribusiness. Despite coming from different sectors, participants shared a consistent view of the drivers, constraints, and priorities that shape salinity management in Egypt.

a) Salinity is a multi dimensional and rapidly intensifying challenge

Across all interviews, and also a central finding of the literature review, there was broad agreement that salinity is increasing in severity and complexity, driven by seawater intrusion in the northern Delta, shallow and rising groundwater, reuse of saline drainage water, and inefficient irrigation and drainage systems. Multiple experts noted that without coordinated interventions, the expansion of salinity will continue to reduce productivity, particularly in the Nile Delta, Western Desert and reclamation areas.

b) Drainage infrastructure is central to any long term solution

One of the most consistent messages from nearly all experts, and again, also from the literature review, is that drainage quality and water use are the cornerstones of salinity control. Many networks are clogged, under maintained, or incomplete, resulting in stagnant water tables and salt accumulation in the root zone. Experts emphasized that drainage rehabilitation, maintenance units within Water Users Associations, and the separation of irrigation and drainage canals are urgent priorities.

c) Irrigation modernization

While modernization (e.g., drip or sprinkler systems) improves water-use efficiency, the experts warned that such systems can worsen salinity if leaching requirements are ignored. Several participants noted that farmers lack guidance on how, when, and how much to leach under different soil and water conditions.

d) Soil health interventions are essential

Experts stressed that soil amendments such as including gypsum, compost, biochar, and other organic materials; play an important role in improving soil structure, reducing sodicity, and enhancing infiltration. This was also clear from the literature review, although it was mostly considered effective under specific salinization causes. Additionally, these measures need to be part of a broader integrated package that also includes proper drainage, irrigation scheduling, and monitoring. Soil improvements alone cannot address the root causes of salinity without complementary hydrological management.

e) Tailored, region specific packages are needed

All stakeholders highlighted strong regional differentiation in salinity drivers and conditions, and the literature review agrees with this. For example, the northern Delta requires interventions addressing seawater intrusion and shallow groundwater; Fayoum faces evapoconcentration in a closed basin; desert reclamation areas deal with brackish groundwater and weak drainage; and Sinai suffers from brackish sources and limited freshwater. Experts repeatedly stressed that salinity management must be spatially customized and not based on generic recommendations, and this suggestion has been followed throughout the rest of this report.

f) Data gaps and inconsistent monitoring hinder effective planning

The interviews consistently pointed to a lack of up-to-date, accessible, and standardized data on soil and groundwater salinity. This also came out of the literature review, albeit not that frequent and specific. Many Experts suggested that current decision-making processes would benefit from the integration of updated datasets and a more unified approach to local monitoring efforts. There was widespread support for creating a National Salinity Observatory or an equivalent centralized platform that integrates remote sensing, field EC measurements, groundwater data, and drainage system performance.

g) Institutional fragmentation and weak coordination limit impact

Government and research stakeholders emphasized that responsibilities for salinity management are split between ministries and agencies, resulting in overlapping mandates and weak enforcement. Experts argued that without stronger coordination, shared data, and consistent regulatory follow-through, technical interventions will not achieve their intended outcomes. The decline of extension services was also noted as a major barrier to translating policy and research into practice.

h) Farmer adoption is constrained by cost and trust

Experts with field experience reported that many farmers are aware of salinity but lack the financial means, technical guidance, or confidence to adopt new practices. For this reason, we added table 2 to the literature review, in order to exemplify the benefits of certain interventions under specific conditions. Misdiagnosis of salinity symptoms is common, and mistrust of unverified inputs slows adoption. Demonstration plots, economic evidence, and diagnostic services were repeatedly cited as necessary to bridge the gap between recommended solutions and real-world practice.

Summary of the stakeholder insights

- Pillar 1: Drainage & Governance: Interviews 1, 2, 7 → Rehabilitate drainage systems.
- Pillar 2: Irrigation + Leaching: Interviews 1, 4, 6, 8, 9 → Modernize Irrigation systems.
- Pillar 3: Soil Health: Interviews 3, 5, 6 → Organic matter, gypsum, pH correction, raised beds.
- Pillar 4: Crops & Protected Agriculture: Interviews 1,2, 3, 5, 9→ Tolerant varieties, greenhouses, hydroponics, seed and resistance varieties.
- Pillar 5: Monitoring & Policy Integration): Interviews 1, 3, 8 → National Salinity Observatory, soil testing, enforcement.

2. Salinity Roadmap

2.1 From fragmented interventions to a coherent 2035 strategy

Salinity has been on Egypt's agricultural and water-management agenda for decades. Numerous projects, pilots, policy initiatives, and capacity-building programs have been implemented by national institutions, development partners, and the private sector. As a result, all major categories of salinity interventions already exist in practice today—from drainage rehabilitation and irrigation modernization to salt-tolerant crops, protected agriculture, water reuse, and monitoring initiatives.

However, these efforts form a diffuse and fragmented landscape. Activities are often implemented in parallel rather than in synergy, guided by different problem framings, incentives, and institutional mandates. Decision-making power is spread across ministries, governorates, research bodies, and donors, but coordination mechanisms remain, unfortunately, weak. Consequently, salinity- and climate-oriented agriculture has not yet become standard practice, despite decades of investment and knowledge generation. Evidence from the literature review and stakeholder interviews points to four reasons why salinity-smart agriculture has not become mainstream yet:

1. **Mismatch between interventions and salinity mechanisms**
   Solutions are often applied uniformly, while salinity in Egypt is driven by fundamentally different processes (irrigation-driven, drainage-driven, coastal/climate-driven, and primary/geogenic).
2. **Fragmented intervention packages**
   Single measures (e.g. drip irrigation, compost, or tolerant varieties) are commonly promoted without the complementary measures needed for them to work (e.g. drainage, leaching protocols, monitoring).

3. **Weak feedback loops**
   Monitoring, learning, and adaptation are insufficiently embedded, so lessons learned are not always applied in subsequent projects.
4. **Limited institutional anchoring**
   Many interventions remain project-based and are not embedded in regulations, extension systems, budgeting routines, or accountability structures.

Strategic Vision for 2035:

Addressing salinity in Egypt requires a long-term, coordinated perspective that moves beyond isolated interventions toward systemic and preventive management. Given the growing pressures from climate change, water scarcity, and land degradation, a clear strategic direction is needed to guide investments, policies, and on-the-ground action. **Goal:** By 2035, Egypt has a salinity- and climate and water-resilient agricultural system in which differentiated, evidence-based intervention packages are routinely applied, aligned across institutions, and embedded in policy, markets, and practice.This roadmap is structured around four salinization types identified in the report. Each type requires a distinct but integrated package of interventions.

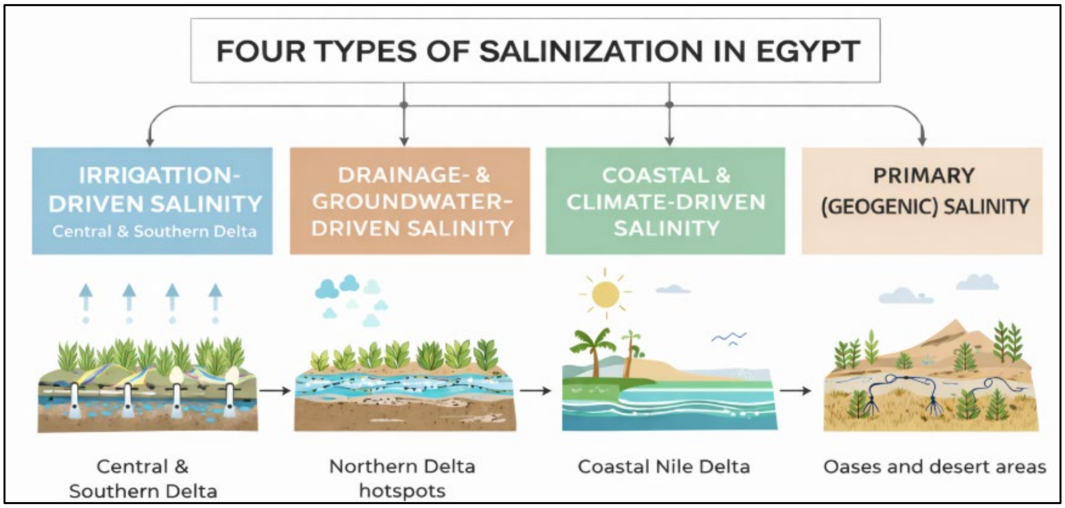

Figure 5: Four types of salinization in Egypt

1. Irrigation-Driven Salinity (large parts of central and southern Delta)

Salt accumulation due to evapotranspiration, inefficient irrigation, and insufficient planned leaching.

Effective integrated package:

- Smart irrigation scheduling with explicit leaching fractions
- Field-level water management (raised beds, land leveling)
- Soil health improvement (organic amendments, structure restoration)
- Crop and variety selection aligned with salinity levels
- Routine soil and water EC monitoring

Embed leaching protocols and soil diagnostics into extension services, irrigation modernization programs, and performance indicators.

2. Drainage-and Groundwater-Driven Salinity (northern Delta hotspots)

Shallow groundwater and capillary rise caused by deteriorated or poorly managed drainage systems.

Effective integrated package:

- Rehabilitation and maintenance of subsurface drainage
- Controlled drainage to balance leaching and water conservation
- Coordinated operation across farms and water-user groups
- Complementary soil-structure improvement
- Monitoring of groundwater depth and salinity

Clarify mandates, financing, and accountability for drainage operation and maintenance, and link drainage performance to agricultural productivity outcomes.

3. Coastal and Climate-Driven Salinity (coastal Nile Delta)

Seawater intrusion and climate change processes operating beyond field scale.

Effective integrated package:

- Groundwater abstraction management and monitoring
- Controlled reuse and blending of marginal water
- Land-use adaptation and crop zoning based on salinity risk
- Nature-based and engineered coastal protection measures
- Strategic use of protected agriculture for sensitive crops

Integrate salinity into coastal-zone management, climate adaptation planning, and long-term land-use decisions, acknowledging limits to remediation.

4. Primary (Geogenic) Salinity (oases, closed basins, desert areas)

Salinity is structurally embedded and cannot be removed.

Effective integrated package:

- Salt-tolerant crops and halophytic systems
- Protected agriculture and soil-decoupled production systems
- Soil management for productivity rather than desalination
- Adaptive land-use planning and possible re-zoning

Shift policy objectives from reclamation to adaptation, preventing repeated investment in technically ineffective remediation.

2.2 Phased pathway toward system change (2026–2035)

The roadmap is intended as a nationally owned framework implemented through coordinated action among Egyptian institutions. Given the central role of water and drainage management in salinity dynamics, the Ministry of Water Resources and Irrigation is well positioned to act as the coordinating anchor, working in close partnership with the Ministry of Agriculture and Land Reclamation and other relevant authorities. Additionally, the framework proposed here with the four types of salinization in Egypt, and associated packages of interventions is something that needs to be established and researched further. Further scientific investigation into these four types of salinization, as well as the identification of additional effective intervention methods, as well as quantifying the level of effectiveness of different interventions, will help policy makers focus their efforts effectively. A continued scientific endeavour into these issues will ensure an active discussion on the topic and will keep the topic 'alive'.

To move from today's fragmented intervention landscape toward a coherent and institutionalized approach by 2035, the roadmap outlines a set of mutually reinforcing actions. While these actions are presented in phases to indicate possible starting points and areas of emphasis, they are not intended to be strictly sequential. In practice, many of these actions can and should be implemented simultaneously. The pathway is therefore best understood as an adaptive and interconnected process, in which progress in one area supports and accelerates progress in others. Running actions in parallel allows institutions to learn, adjust, and build momentum over time, ultimately strengthening system-wide salinity management.

Capacity development and education are important cross-cutting enablers throughout this pathway, but it has not specifically mentioned in the steps described below. This has also been mentioned during one of the workshops we held towards creating this roadmap. Strengthening knowledge on responsible land and water management among students and young professionals in agricultural and water-related fields is essential for long-term impact. Integrating these topics into relevant curricula—supported by the Ministry of Education and sectoral institutions—can help ensure that future practitioners are equipped to apply salinity-smart approaches. This contributes to smoother implementation of the roadmap and supports more resilient food production and water management in Egypt over the long term.

Step 1 (2026–2027): Make the Existing Landscape Explicit and Comparable

The first step toward a coherent salinity strategy is to create a shared and explicit understanding of what already exists. Given that salinity-related interventions have been implemented in Egypt for decades by multiple actors, this phase focuses on making the current landscape visible, comparable, and discussable across institutions.

During this step, existing salinity-related projects, policies, investment programs, scientific publications and operational practices are systematically mapped across ministries, governorates, development partners, academia and the private sector. The purpose is not to evaluate individual projects, but to clarify how different interventions, rationales, and priorities currently coexist, sometimes reinforcing each other, sometimes working at cross-purposes. This report can serve as a starting point for this step.

At the same time, the four salinity mechanisms identified in this report can be operationalized as a common analytical language within key institutions, particularly the Ministry of Water Resources and Irrigation (MWRI), the Ministry of Agriculture and Land Reclamation (MALR), and the Egyptian Public Authority for Drainage Projects (EPADP). Rather than remaining a research classification, this typology is advised to be translated into practical diagnostic categories that can be used by planners, engineers, extension officers, and decision-makers when assessing problems and selecting interventions. At the same time, continued scientific research into the four types of salinization remains very relevant, as well as continuing scientific research into effective measures. International and mutual learning can be very effective in deepening our scientific understanding of different types of salinization as well as of effective measures, and for this European COST Actions can be very effective. Currently, there is a COST Action specifically about salinity, the COST Action SUSTAIN, and in this action global expertise on salinization is united and actively collaborating. Additionally, the Action offers funding for a number of different activities such as conferences and training schools, but also for mutual learning via the availability of Short-Term Scientific Missions. This Action can be very relevant for the further development of this roadmap.

Building a shared framework, governorate-level salinity profiles should be developed. These profiles combine information on soil salinity, groundwater depth and quality, drainage performance, dominant cropping systems, and land-use characteristics. By linking biophysical data to institutional responsibilities at governorate level, and the latest scientific insights, these profiles create a bridge between national strategies, up to date knowledge and local decision-making.

By the end of this step, salinity is ideally no longer treated as a diffuse or generic problem, but as a set of clearly differentiated challenges with identifiable institutional entry points, properly grounded in scientific knowledge.

Step 2 (2027–2029): Align Interventions into Integrated Packages

Building on a shared understanding of salinity mechanisms, this step focuses on changing how interventions are designed and implemented in practice. The central idea is to shift from isolated, single-measure projects toward integrated intervention packages that jointly address irrigation, drainage, soil management, crop choice, and monitoring, in line with the dominant salinity mechanisms in each context.

Ongoing and planned initiatives are reviewed and, where necessary, reconfigured so that measures reinforce rather than undermine each other. Irrigation modernization is explicitly linked to leaching requirements and drainage performance, while soil amendments and salt-tolerant crops are applied as complementary elements within a broader water-management strategy in those regions where these interventions have proved effective. Governorate-level coordination mechanisms support alignment between MWRI, MALR, EPADP, research institutes, and Water User Associations, ensuring coherent use of existing mandates.

Step 3 (2029–2031): Embed Monitoring, Learning, and Feedback Loops

Existing data on soil salinity, groundwater levels, drainage-water quality, and crop performance are progressively aligned and standardized. A coordinated national salinity monitoring function strengthens data harmonization and interpretation without creating parallel institutions.

Monitoring results are directly linked to operational decisions on water allocation, leaching, drainage operation, and extension advice.

Embedding feedback loops reduces the repetition of ineffective interventions and provides the evidence base required for responsible scaling.

Step 4 (2031–2033): Align Incentives, Markets, and Finance

Once integrated approaches are technically established and supported by monitoring, economic incentives become the main determinant of adoption. This step focuses on aligning finance, markets, and investment decisions with salinity- and water-smart practices.

Access to public support, credit, and investment incentives is increasingly linked to the adoption of integrated salinity management, particularly for capital-intensive measures such as drainage rehabilitation, controlled water reuse, and protected agriculture. In parallel, salinity and water-efficiency considerations are embedded in value-chain standards, export certification, and contract farming arrangements, creating market-based rewards for resilient production systems. This alignment ensures that economic signals reinforce, rather than undermine long-term system performance.

Step 5 (2033–2035): Institutionalize and Normalize Salinity-Smart Agriculture

The final step focuses on embedding salinity- and climate-resilient practices permanently within Egypt’s institutional framework. By this stage, proven approaches are no longer treated as projects, but as standard practice.

Differentiated salinity management is integrated into regulations, technical standards, extension curricula, and professional training. Long-term arrangements for drainage operation and maintenance are formalized, and salinity considerations are embedded in land-use planning, coastal management, and climate adaptation strategies, explicitly recognizing where adaptation rather than remediation is the appropriate policy choice.

By 2035, salinity- and climate-smart agriculture will be -ideally- institutionalized within the routine functioning of Egypt’s water, agriculture, and land-use systems.

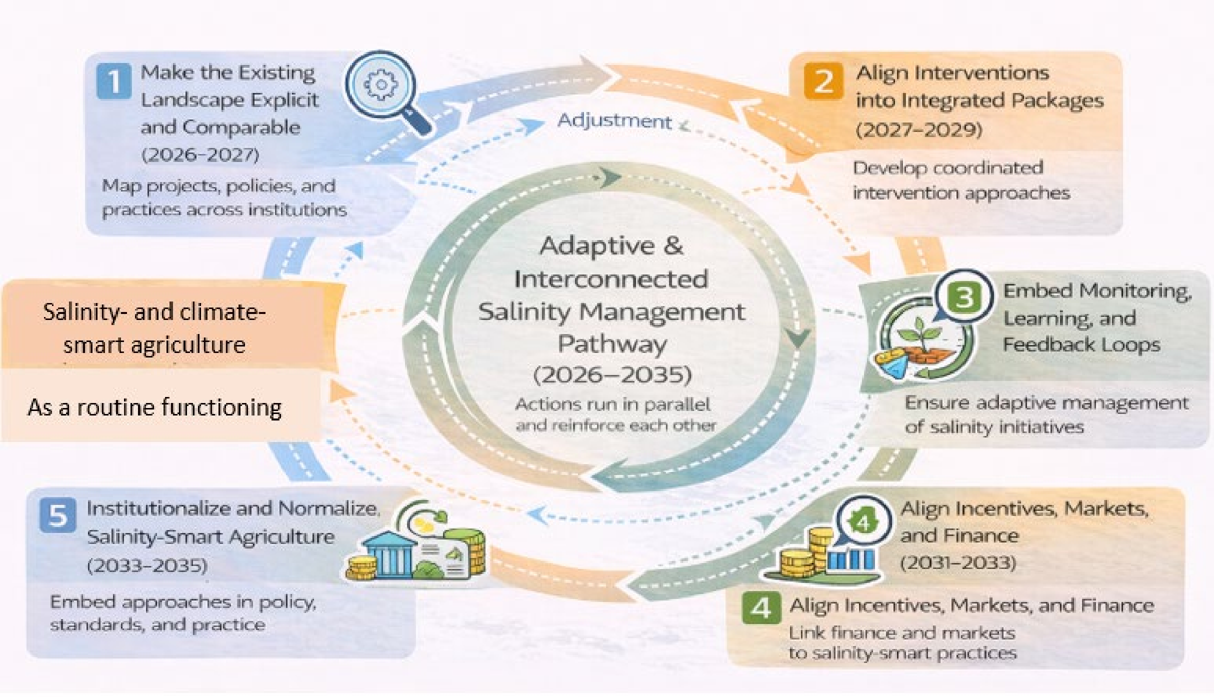

Figure 6: Salinity management pathway (2026–2035)

3. Bottleneck Assessment

While the roadmap articulates where Egypt needs to go by 2035 and how system change can be sequenced and institutionalized, the bottleneck tables below translate this strategic direction into the practical constraints that currently prevent salinity- and climate-smart agriculture from becoming standard practice. Importantly, the identified bottlenecks do not represent gaps in knowledge or a lack of technical solutions; rather, they reflect misalignments between salinity mechanisms, intervention packages, institutional mandates, financing structures, and implementation capacity.

As such, the bottlenecks cut across all roadmap steps: they explain why earlier phases (diagnosis, alignment, and integration) are essential preconditions for later phases (scaling, market integration, and institutionalization). Each bottleneck category—technical, economic, institutional, social, and capacity-related—can be directly linked to one or more steps in the roadmap and to specific salinity types, reinforcing the roadmap's core premise that system change requires coordinated action across domains rather than isolated fixes.

The following tables therefore serve as a structured reference framework to guide prioritisation, sequencing, and responsibility allocation during roadmap implementation, while remaining fully consistent with the differentiated, mechanism-based and policy-oriented approach outlined in the roadmap.

The following abbreviations are used throughout this section: MWRI refers to the Ministry of Water Resources and Irrigation; MWRI (GW) refers to the Ministry of Water Resources and Irrigation – Groundwater Sector; MWRI (coastal) refers to the Ministry of Water Resources and Irrigation – Coastal Protection Sector; MALR refers to the Ministry of Agriculture and Land Reclamation; EPADP refers to the Egyptian Public Authority for Drainage Projects; ARC refers to the Agricultural Research Center; and WUAs refers to Water User Associations.

A. Technical Bottlenecks

Bottleneck	Region(s)	Roadmap Actions & Phases	Financing Mechanisms	Responsibility Centers
Subsurface drainage deterioration	Northern & Central Delta	Drainage rehabilitation; controlled drainage pilots (P2–P3); operational institutionalization (P5)	National budgets, development programs, co-funded pilots	EPADP, MWRI, Governorates, WUAs
Irrigation modernization without leaching	Delta & reclaimed lands	EC-based scheduling; leaching guidance; raised beds; demonstration hubs (P2–P3); integration into extension (P5)	Extension budgets, pilots, private sector services	MALR/ARC, MWRI, Governorate extension units
Unregulated drainage-water reuse	Delta	Water Reuse Hubs; monitored blending; reuse thresholds (P2–P5)	Public works, user contributions	MWRI, EPADP, Governorates
Brackish groundwater + weak drainage	Reclaimed /desert lands	Blending/desalination; soil organic matter; efficient irrigation; brine management; aquifer rules (P2–P5)	PPPs, investor capex, targeted grants	MWRI (GW), MALR, private farms

Coastal seawater intrusion	Coastal Delta	Coastal protection; nature-based buffers; groundwater abstraction management; adaptive land use (P1–P5)	Public infrastructure, partnerships	MWRI (coastal), Governorates
Primary salinity	Oases & closed basins	Salt-tolerant crops; halophytes; protected agriculture; land-use zoning (P2–P5)	Seed programs, protected agriculture investments	MALR/ARC, local administrations

B. Economic & Financial Bottlenecks

Bottleneck	Actions & Phases	Financing Mechanisms	Responsibility Centers
High capex & liquidity constraints	Demonstrations leading to credit schemes; PPPs for protected horticulture (P2–P4)	Credit lines, blended finance, PPPs	MALR, Governorates, financial institutions
Underfunded O&M	Mandated O&M budgets; WUA maintenance units; performance-based arrangements (P5)	Public O&M budgets, user contributions	EPADP, MWRI, WUAs

C. Policy & Institutional Bottlenecks

Bottleneck	Actions & Phases	Financing Mechanisms	Responsibility Centers
Fragmented mandates	Coordination platforms; salinity task teams; harmonized protocols (P1 onward)	Government budgets, partner support	MWRI, MALR, EPADP, ARC, Governorates
Weak standards & extension	Codify standards; integrate into curricula; link to certification schemes (P3–P5)	Training budgets, development programs	MALR/ARC, MWRI, Governorates

D. Social, Cultural & Inclusion Bottlenecks

Bottleneck	Actions & Phases	Financing Mechanisms	Responsibility Centers
Farmer adoption barriers	Demonstration hubs; low-cost diagnostics; EC-based scheduling tools (P2–P3)	Grants; diagnostic service fees	Extension services, advisory providers
Smallholder exclusion	Low-complexity protected systems; cluster hubs; tailored financing (P2–P4)	PPPs, smallholder credit	MALR/extension, private operators

E. Capacity Bottlenecks

Bottleneck	Actions & Phases	Financing Mechanisms	Responsibility Centers
Skills gaps	Centers of Excellence; training-of-trainers; operational SOPs (P2–P5)	Training programs	ARC, universities, MWRI
Weak monitoring & analytics	Unified monitoring systems; shared data protocols; periodic zoning (P1–P3)	Government & partner support	MWRI, MALR, EPADP, ARC

In summary, the bottleneck tables reveal a set of consistent patterns that have important implications for how the roadmap should be interpreted and implemented. Across all categories, bottlenecks tend to cluster around the interaction between salinization mechanisms, intervention choices, and institutional arrangements, rather than around the feasibility of individual measures.

One thing that stands out is that the nature and intensity of bottlenecks differ by salinization type. In irrigation- and drainage-driven salinity systems, bottlenecks are most pronounced in coordination, operation and maintenance, and the alignment of irrigation, drainage, and agronomic practices. In coastal and climate-driven salinity contexts, constraints are more strongly linked to scale mismatches, long-term planning, and the limits of field-level interventions. In areas affected by primary salinity, bottlenecks frequently reflect continued investment in remediation approaches that are technically ineffective, pointing to the need for clearer adaptation-oriented policy choices.

Across all salinity types, the tables show that bottlenecks are cumulative and reinforcing. Technical constraints are often exacerbated by institutional fragmentation, limited incentives, and weak feedback mechanisms, which in turn reduce the effectiveness of otherwise sound interventions.

From a temporal perspective, the bottlenecks help clarify why progress depends on addressing foundational constraints early. Issues related to shared diagnostics, coordination, and learning must be tackled in the initial phases in order to reduce downstream bottlenecks related to scaling, finance, and institutionalization. Conversely, attempting to scale or institutionalize practices without resolving these earlier constraints is likely to reproduce existing inefficiencies.

Overall, the bottleneck analysis reinforces the roadmap's central proposition: achieving salinity- and climate-resilient agriculture in Egypt requires not additional interventions, but more deliberate alignment of existing ones, differentiated by salinization mechanism and implemented through a phased process that connects technical action with institutional change.

4. Market opportunities for Dutch companies

4.1. Previous and Current projects funded by (or co-funded by) Dutch Government

The collection of the Netherlands Enterprise Agency (RVO) supported initiatives reviewed in this section illustrates a multi-level and strategic response to these complex challenges, combining direct saline agriculture interventions with a robust set of indirect enabling projects. Collectively, these projects form diversified project themes that not only address the challenges of salinization but also tackle its structural causes ranging from poor drainage to inefficient irrigation, limited farmer capacity, and fragmented land governance.

4.1.1. Part I: Direct Salinity Projects

1) Development of Saline Agriculture in Egypt with Brackish Groundwater (PVW4)

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-pvw4s17038

This initiative investigates the technical and commercial viability of saline agriculture under brackish groundwater conditions, with attention to Egypt's northern coastal zones where brackish aquifers are prevalent. It targets high priority horticulture expansion while acknowledging constraints from declining freshwater availability and the strategic need to reduce dependence on Nile water.

The project pursues: (i) soil and water characterization to define feasible ranges for cultivation; (ii) techno-economic designs for both greenhouse and open-field systems; (iii) crop testing initially for tomato (greenhouse), carrot, onion, and possibly potato (open-field); (iv) on-site assessment of groundwater extraction and treatment costs; and (v) financial feasibility benchmarking against conventional freshwater farming. Crucially, it seeks a strategic business model to enable scaling.

Expected outcomes include 50–70% savings in freshwater (higher in greenhouse systems), 10–30% reductions in fertilizers and pesticides via water recycling, and avoidance of costly desalination at the farm gate—thus improving viability for smaller growers. The project also emphasizes solar energy integration for water treatment, aligning water-energy-food synergies.

As a proof-of-concept and design blueprint, this project is pivotal: it quantifies trade-offs and identifies operational envelopes (salinity thresholds, treatment costs, crop performance) required to mainstream brackish-water horticulture in Egypt.

2) Impact Cluster: DESALT: Dutch-Egyptian Saline Farming & Water Management Technology

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-psi10eg24

DESALT is a Dutch Egyptian collaborative project designed to demonstrate, validate, and scale saline farming and smart water management techniques under degraded soil and saline water conditions in Egypt. Unlike isolated field trials, the initiative focuses on on-farm demonstrations, capacity building, and practical business cases to support broader adoption of saline agriculture. It is co-funded by the Netherlands Enterprise Agency (RVO) under the Impact Cluster programme and implemented by a consortium that includes The Salt Doctors, Delphy, Nectaerra, IV-Water, SEKEM, Worood, HZPC-Egypt, and MK Farm.

Key trials and demonstrations under DESALT include:

- Potato cultivation under saline conditions: At Sekem Farm, trials evaluated multiple potato varieties on salt-affected soils (seasonal mean soil salinity ~5.5 dS/m). Four out of eight varieties achieved yields around 32 ton ha^{-1}. Using high levels of compost improved yields by 27–54%, and cost-benefit analysis showed profit increases of up to ~14% at low market prices, rising to ~88% at typical Egyptian market prices. This demonstrated that compost application combined with varietal selection can offset salinity constraints.
- Onion cultivation improvement: Worood Farm implemented trials to refine saline water strategies for onion production under drip irrigation.

- Irrigation management experiments: Partners like Nectaerra tested irrigation efficiency under saline conditions, including drip systems, Agroforestry and soil-water interactions, generating actionable insights on optimizing water use in salt-affected fields.

Across these sites, crops such as potato, beetroot, cauliflower, tomato, sorghum, cowpea, and clover species were used to evaluate salinity responses, soil amendments, and cultivation methods. Demonstrations also served as training platforms for farmers, extension agents, and agribusiness practitioners, combining field learning with consultancy, e-learning, and group sessions

3) ProSal-Hydro: Hydroponic Methods to Combat Soil Salinity and Water Scarcity

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-pvw5s23079

ProSal-Hydro targets smallholder farmers, introducing low-complexity hydroponic systems that save water and enable reuse of saline drainage water without aggravating sodicity or salinity in clay soils of the Delta. It directly counters soil-borne salinity constraints by decoupling plant roots from degraded soils.

The project provides systems plus know-how, aiming for yield increases, income gains, and entrepreneurship opportunities, while contributing to SDG 6 (water efficiency) and SDG 15 (sustainable use of terrestrial ecosystems). For smallholders facing rising input costs and shrinking water allocations, ProSal-Hydro proposes a capitalize-light path toward salinity resilience.

Hydroponics is often perceived as capital-intensive; by adapting “easy sustainable” designs and localized training, this project explores a scalable entry point for resource-constrained farmers to maintain production under saline conditions.

4) EU SALAD: Saline Agriculture for Adaptation

EU SALAD promotes saline agriculture as a climate-adaptation strategy by testing and scaling salt-tolerant crops, cultivation practices, and value chains suited to saline environments. Working across Europe and North Africa, including Egypt, the project addresses the growing challenge of soil and water salinization driven by climate change, sea-level rise, and freshwater scarcity.

The project combines field experimentation, farmer engagement, and market analysis to identify viable saline-adapted cropping systems and to strengthen knowledge exchange between research institutions, practitioners, and policymakers. By linking agronomic innovation with value-chain development, SALAD aims to make saline agriculture both technically feasible and economically attractive.

Rather than focusing only on mitigation, SALAD frames salinity as a condition to adapt to. It supports crop diversification, salt-tolerant varieties, and improved soil-water management, contributing to climate-resilient food systems and SDG 2 (food security) and SDG 13 (climate action). For regions facing increasing salinity, SALAD explores how agriculture can remain productive under changing environmental conditions.

3) JCAR: Coping with Increasing Salinity to Maintain Agricultural Productivity in the Northern Delta

The project is part of the Joint Cooperation in Applied Research Programme – Water (JCAR), a collaboration between Egypt and the Netherlands. The partnership brings together major Egyptian institutions including the Soil, Water and Environment Research Institute (SWERI), Water Management Research Institute (WMRI), and other bodies of the National Water Research Center (NWRC), and Dutch research organizations such as Wageningen University & Research (WUR) and Deltares. The initiative is funded by the Embassy of the Kingdom of the Netherlands in Egypt and forms a bilateral applied-research cooperation aiming to generate practical, field-tested solutions for improving agricultural resilience under salinity stress. The project addresses an urgent challenge in the Northern Nile Delta which increases soil and water salinity caused by seawater intrusion, shallow saline groundwater, and the growing reliance on mixed or drainage water for irrigation, particularly in downstream canal areas. These pressures threaten crop productivity, water efficiency, and long-term soil health in a region with heavy clay soils and limited natural leaching.

To tackle this problem, the project implemented two long-term field pilots (2023–2025) in Kafr El-Sheikh governorate, each designed to test a different category of interventions. A Pilot located in Shaba (Desouq), which evaluates the impact of modern drip irrigation versus improved flood irrigation under freshwater conditions but with saline groundwater risk; it included five consecutive cropping seasons (maize, wheat, watermelon seeds, sugar beet, and rice).

A Pilot in Sidi Salem assessed soil salinity management strategie such as gypsum application, leaching requirements, and mole drains under moderately saline irrigation water, across four cropping seasons. Experimental activities included detailed monitoring of soil salinity at multiple depths, irrigation volumes, drainage behavior, nutrient dynamics, crop yields, and farmer income, combined with stakeholder interactions and long-term modelling to understand cumulative impacts and scalability.

The results showed that while drip irrigation improved yields by 13–24%, saved 20–30% water, and increased farmer income, it also led to gradual soil salinity accumulation unless complemented by deliberate leaching or the introduction of a high-water-use crop like rice, which reduced accumulated salts by ~25%. Conversely, in the saline area, the combined strategy Gypsum + Leaching + drains reduced soil salinity by 19–40%, improved yields by up to 45%, and increased farmer income, though it required 6–27% more irrigation water to achieve the needed salt removal.

The project recommends integrating irrigation modernization with active salinity-management practices, adjusting irrigation scheduling to include leaching requirements, strengthening drainage, and considering crop rotations that periodically restore soil quality. These findings highlight the need for location-specific, water-balanced strategies to ensure productivity gains without compromising long-term soil health in the Nile Delta.

4) Enhancing Climate Change Adaptation in the North Coast and Nile Delta

Project page: https://www.undp.org/egypt/projects/enhancing-climate-change-adaptation-north-coast-and-nile-delta-egypt

The Enhancing Climate Change Adaptation in the North Coast and Nile Delta project, supported by the United Nations Development Programme (UNDP) and funded by the Green Climate Fund, aims to reduce the risks of coastal flooding and other climate change impacts along Egypt's Nile Delta and North Coast.

The densely populated low-lying lands of the delta are highly vulnerable to projected sea-level rise and more frequent extreme weather events, which in turn increase the risk of saline intrusion into groundwater and agricultural soils and threaten coastal infrastructure, livelihoods, and prime agricultural land. To address these risks, the project implements a combination of physical protection and integrated planning measures.

Key project activities include the construction of approximately 69 km of sand dune dikes in five vulnerable hotspot locations within the Nile Delta to protect against storm surges, and the development of an Integrated Coastal Zone Management (ICZM) plan for the North Coast to guide long-term climate adaptation planning and risk reduction. The ICZM plan incorporates systematic coastal monitoring of oceanographic parameters, shoreline dynamics, and the effects of climate change on coastal erosion and stability, ensuring that climate risks are integrated into coastal development and management policies.

4.1.2. Part II: Indirect (Salinity-Relevant) Projects

1) RootGrow Cluster Project: Citrus Sector Irrigation and Rootstock Innovation

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-pic19eg01

In Egypt's citrus sector, flood irrigation drives excessive water losses and evaporative salt accumulation in soils. RootGrow aims to modernize irrigation and introduce new rootstocks to enhance water productivity and salinity tolerance, thereby improving yields, fruit quality, and profitability.

While not a saline farming project per se, preventing salt buildup through improved irrigation is a first-order salinity mitigation strategy in arid irrigated systems. The project's water savings also free up freshwater, easing pressure on marginal lands where brackish sources dominate.

2) Identification of Solutions for Egyptian Field Drainage Systems & Scoping Mission on Drainage Possibilities

Project pages: https://projects.rvo.nl/projects/nl-kvk-27378529-pvw4a18048

These two initiatives review design, operation, and maintenance of field drainage, which is fundamental to controlling water tables and salt balance in irrigated agriculture. Effective drainage removes saline leaching and capillary rise, mitigating secondary salinization and preserving soil function.

Without adequate drainage, even modern irrigation devolves into soil salinization over time. These projects address structural constraints that can lock farmers into salinity traps, regardless of on-farm practice improvements.

3) New Land Development Programme: Groundwater Management Consultancy

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-cic24egs14

This assignment supports groundwater management in Egypt's reclaimed "New Lands", where agriculture relies heavily on brackish aquifers. Sound groundwater governance is a non-negotiable precondition for sustainable saline or freshwater farming.

By clarifying extraction costs, safe yields, and quality dynamics, the consultancy underpins decisions on when to treat, blend, or directly use brackish water, and how to avoid salinity in new reclamation tracts.

4) IHE Desalination Training in Egypt

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-pvw525eg05

With 125 desalination plants already operating and plans to expand capacity, Egypt requires specialized plant operation skills—water chemistry, maintenance, energy efficiency, and advanced RO methods. This training strengthens human capital for managing saline water resources at utility scale.

Though not farm-level, desal capacity and expertise relieve system-level pressure and open options for brackish/fresh blends, industrial reuse, and municipal supply buffering, indirectly supporting agriculture by reallocating higher-quality water and reducing draw on freshwater for farms.

5) Saline Futures Conference: Study Visit (MAP19MC06)

Knowledge exchange to expose MENA officials and academics to saline farming innovations and facilitate B2B linkages with Dutch companies.

Policy learning and peer exchange are accelerators of adoption; building shared mental models of what works under salinity helps align public programs, extension services, and private input markets.

6) LAND-at-Scale: Participatory Land-Use Consolidation for Climate Resilience and Inclusive Business Models

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-las24eg1s

Tackles land fragmentation through participatory consolidation, combined with inclusive business models, capacity building, and demonstration plots for climate adaptation.

Consolidation can rationalize irrigation layouts, enable shared drainage investments, and improve water governance across holdings, all of which are vital to landscape-scale salinity management.

7) BUCRA: Building Unity for Climate-Resilient Agriculture

Project page: https://projects.rvo.nl/projects/nl-kvk-27378529-cic24egs11

Leverages digital agronomy and collective farming models to improve practices, stabilize farmer incomes, and create jobs, while amplifying Dutch knowledge packages in Egypt.

Digital tools can optimize irrigation scheduling, salinity monitoring (EC), fertigation, and leaching fractions, supporting precision management that prevents or remediates salinization.

8) Custom-Made NPK Fertiliser Blends

Establishes a local blending facility to tailor NPKs to soil and crop-specific needs, countering the dominance of standard, imported compounds and widespread counterfeiting.

Under saline conditions, ion interactions and nutrient imbalances (e.g., K^+/Na^+ competition, Ca^{2+}/Mg^{2+} for structure) are critical. Custom blends allow corrective nutrition and soil conditioning, r and secondary salinization through mis fertilization.

9) Sustainable Agriculture & Farming Enhancements in Egypt (SAFE)

The SAFE project, implemented by Necterra in partnership with a Dutch consortium and Egyptian agribusinesses Daltex and Dakahlia, aims to demonstrate the productivity, profitability, and long-term sustainability benefits of Dutch regenerative agriculture inputs and practices in Egypt. The initiative focuses on replacing conventional chemical and antibiotic-based farming approaches with innovative soil- and crop-enhancing products, supported by tailored regenerative farming knowledge and application guidance. By improving soil health, strengthening ecosystem resilience, and enhancing farm profitability, SAFE showcases how modern Dutch inputs and regenerative techniques can offer a viable, scalable alternative to traditional input-heavy production systems in Egypt.

4.2. Dutch Private Sector Opportunities in Tackling Egypt's Salinity Challenge

In this section we aim to identify areas where Dutch expertise and private companies can partner with Egyptian institutions to reduce soil and water salinity, improve water efficiency, and strengthen agricultural resilience.

Dutch organizations—from the public sector, private industry, and research institutions—are well-positioned to offer expertise and support at various stages of Egypt's transformation toward water-smart and climate-resilient agriculture. The potential contribution of Dutch expertise to Egypt's salinity challenge can be understood as both phased over time and differentiated by salinization mechanism. The four salinization types identified in this roadmap—irrigation-driven, drainage- and groundwater-driven, coastal and climate-driven, and primary (geogenic) salinity—require distinct intervention packages and governance responses. As a result, the relevance and form of international expertise evolves across roadmap phases and varies by context.

1- Near Term (2026–2027): Building Shared Diagnostics Across Salinity Types

In the initial phase, the primary objective is to establish a shared and explicit understanding of salinity mechanisms, existing interventions, and institutional roles. Dutch expertise can support this phase by strengthening mechanism-based diagnostics across all four salinization types. Experience with integrated water-system analysis, spatial modelling, monitoring frameworks, and decision-support tools can help Egyptian institutions distinguish between irrigation-induced salinity, drainage and groundwater constraints, coastal salinity processes, and structurally saline environments. At this stage, the emphasis is not on deploying new technical solutions, but on improving the ability of planners and decision-makers to match interventions to salinity mechanisms. Additionally, an Egypt-wide monitoring system of soil-and water salinity should be established, and a number of Dutch organizations are well equipped to assist with this.

2- Medium Term (2027–2031): Supporting Integrated Packages Tailored to Salinity Mechanisms

As Egypt moves into the phases of aligning interventions and embedding learning, Dutch expertise could offer support in the design, demonstration, and refinement of integrated intervention packages tailored to specific salinization types.

For irrigation-driven salinity, this includes integrated approaches combining smart irrigation scheduling, leaching strategies, soil health management, and monitoring. For drainage- and groundwater-driven salinity, Dutch experience with drainage design, controlled drainage, groundwater monitoring, and system operation can support efforts to restore and optimize hydrological functioning at field and scheme level. In coastal and climate-driven salinity zones, Dutch knowledge in coastal water management, groundwater abstraction control, water blending, and strategic land-use adaptation can contribute to system-level solutions that go beyond farm-scale measures. In areas affected by primary salinity, Dutch expertise in protected cultivation, soil-decoupled production systems, and salt-tolerant cropping systems can support adaptation-oriented strategies rather than ineffective remediation.

Across all types, the focus during this phase is on joint learning and adaptation, ensuring that intervention packages function as coherent systems rather than as collections of individual technologies.

3- Scaling Phase (2031–2033): Linking Salinity-Specific Solutions to Markets and Finance

Once integrated intervention packages have been validated for different salinity contexts, the challenge shifts toward scaling through markets, finance, and value chains. Here, Dutch expertise in supply-chain management, certification, export standards, and investment models could also be very helpful.

The scaling logic differs by salinity type. In irrigation- and drainage-driven contexts, scaling focuses on mainstreaming improved practices across large areas and embedding them in regular programs. In coastal and primary salinity zones, scaling may be more selective, prioritizing high-value crops, protected systems, or adaptive land-use strategies where economic returns justify investment. Dutch experience in aligning production systems with market requirements can help ensure that salinity-smart practices translate into sustained economic viability.

4- Long Term (2033–2035): Institutionalizing Differentiated Salinity Management

In the final phase, when salinity- and climate-smart agriculture is embedded in regulations, planning, and training systems, Dutch engagement is most effective in the domain of institutional learning and capacity development. This includes supporting the incorporation of differentiated salinity management into curricula, professional training, extension systems, and governance arrangements.

At this stage, the key contribution lies in reinforcing the principle that different salinization mechanisms require different policy and management responses, and that this differentiation becomes standard practice within Egypt’s water, agriculture, land-use, and climate institutions.

Examples of Dutch Expertise Relevant to Salinity Management in Egypt

The tables below present illustrative examples of Dutch companies and organizations with recognized strengths in salinity-related domains and indicate how their expertise could align with Egyptian priorities. The information is compiled from publicly available sources and provided for general informational purposes. While reasonable care has been taken to ensure accuracy, the authors accept no liability for errors, omissions, or the use of this information.

The examples are indicative and intended to demonstrate the range of available competencies and possible collaboration models, rather than to prescribe specific partnerships. The list is non-exhaustive and does not seek to exclude any company or organization. It is intended solely to provide practical examples of relevant expertise and potential areas for cooperation.

Salt-Tolerant Crops and Seed Systems

Company / Organization	Strengths	Possible Role in Egypt
Rijk Zwaan	Breeding of high-quality vegetable varieties (tomato, cucumber, melon) with stress and salinity tolerance traits.	Supply and co-develop salt-tolerant horticultural lines for Delta and reclaimed-land production. Establish demonstration farms in cooperation with local growers.
Bejo Zaden	Open-field vegetable breeder (onion, carrot, brassicas) with germplasm adapted to arid conditions.	Conduct field trials with the Agricultural Research Center (ARC) and private farms; provide training on seed performance under saline irrigation.
Enza Zaden	Breeding for heat and abiotic-stress tolerance with distribution networks in North Africa.	Partner in multi-season field screening; co-develop stress-tolerant varieties for greenhouse and open-field cultivation.
HZPC, Agrico, Meijer Potato, Europlant	Global leaders in certified seed-potato production and storage.	Establish a Salt-Tolerant Potato Platform for variety evaluation under saline irrigation and improved seed storage and logistics.
Wageningen University & Research (WUR)	Global leader in saline agriculture R&D.	Provide scientific oversight and phenotyping protocols for salt-tolerance screening in collaboration with ARC.
The Salt Doctors	Specialist consultancy in saline agriculture and water-management practice.	Deliver field-diagnostic services, farmer training, and integrated soil–water–crop management in saline zones; coordinate Dutch–Egyptian knowledge transfer.

Water Management, Mapping & Monitoring

Company / Organization	**Strengths**	**Possible Role in Egypt**
Deltares	Groundwater–surface-water modelling, salt-intrusion analysis, coastal and ICZM expertise.	Lead design of a National Salinity Observatory; model groundwater–seawater interfaces and drainage-water reuse scenarios.
Acacia Water	Practical hydrogeology, aquifer recharge, and monitoring systems.	Implement on-farm water-balance pilots and EC-sensor networks; train MWRI engineers in data interpretation.
IG Water / HydroLogic	Digital water-management platforms and decision-support systems.	Deploy HydroNET dashboards for real-time irrigation and drainage management.
Witteveen+Bos	Engineering and design of water-infrastructure systems.	Rehabilitate and modernise Egypt's tile-drain networks with controlled-drainage retrofits.
Boskalis	Dredging, land reclamation, and coastal protection.	Execute coastal and outlet-channel works to limit seawater intrusion; integrate with MWRI's ICZM plans.
The Salt Doctors	Salinity mapping and field-scale mitigation planning.	Translate Deltares/Acacia modelling results into actionable on-farm and community interventions.
Eurofins	Advanced soil, water, and environmental laboratory testing, including nutrient profiling, soil health indicators, contaminants (heavy metals, hydrocarbons, PFAS,	Provide high-precision soil and water analytics for salinity hotspots; establish standardized testing protocols; support the National Salinity Observatory with laboratory baselines; and build diagnostic

	pesticides), and microbiome diagnostics.	capacity through ISO-accredited methods training.
Normec	Comprehensive testing for groundwater, surface water, wastewater, contaminants (PFAS, heavy metals, hydrocarbons), soil quality, manure, nematodes, and biodegradability assessments	Support environmental and agricultural monitoring through accredited soil- and water-quality testing; assist in contamination mapping in drainage basins; strengthen fertilizer and soil-improver testing; and help build robust water-quality surveillance systems.

Sustainable Farming Practices & Soil Management

Organization	**Strengths**	**Possible Role in Egypt**
Delphy	Practical crop and greenhouse advisory, demonstration-farm design, farmer coaching.	Establish Salinity-Smart Farm Hubs combining raised-bed cultivation, compost use, and irrigation scheduling; train extension agents.
The Salt Doctors	Applied saline-agriculture expertise linking soil chemistry, irrigation, and cropping systems.	Conduct field diagnostics, salinity mapping, and adaptive farming guidelines for Egyptian Delta farmers.
WUR	Soil-fertility and regenerative-agriculture research.	Co-develop training curricula for soil and compost management under saline conditions.
Dutch soil-improvement SMEs(e.g., Den Ouden, Agrifirm)	Compost and bio-fertiliser innovation.	Supply soil-health inputs and support pilot composting facilities under the ASAP programme.

Healthy Soil	Integrated soil-management programs, soil/plant/water diagnostics, microbial & organic soil amendments, customized soil-health formulations, and expert agronomic support	Provide soil-health diagnostics, custom soil-improvement programs, AME® soil enhancement solutions, and salinity-mitigation strategies for Delta and new-land farms.
Aminocore	Producer of high-purity natural L-amino-acid fertilizers & biostimulants; organic, environmentally friendly inputs for stress reduction, soil health, and improved nutrient efficiency.	Supply efficient amino-acid biostimulants for saline & stress-prone areas; enhance nutrient uptake, soil structure, stress tolerance, and resilience within Egypt's salinity-smart programs.
Croptivate	Dutch knowledge company offering crop-nutrition strategies based on energy–nutrient–stimulant systems; soil/leaf-sap analysis; customized biostimulants and neutraceuticals	Deliver integrated crop-nutrition advice, improve performance in saline/nutrient-imbalanced soils, introduce stimulants & coatings, and strengthen farmer decision-making.

Smart Irrigation and Efficient Water Use

Company / Organization	Strengths	Possible Role in Egypt
Hydrosat/Irriwatch/Eleaf	Satellite-based irrigation advisory using remote-sensing and energy-balance models.	Provide field-specific irrigation scheduling and evapotranspiration analytics for Delta farms.
HydroLogic (HydroNET)	Cloud-based water-information and decision-support platform.	Deliver real-time irrigation allocation and alert systems for MWRI and irrigation districts.
VanderSat (Planet)	Satellite soil-moisture data analytics.	Support drought and salinity early-warning and calibration of irrigation models.
SmartFarm	IoT sensor networks and automated irrigation control.	Deploy sensor-based drip-irrigation systems for smallholders; link to IFAD/ASAP demonstration farms.
Nijhuis Saur Industries	Modular desalination and water-reuse technology.	Couple on-farm water-treatment units with drip irrigation to lower EC of brackish water.
Acacia Water & WUR	Irrigation-efficiency and managed-aquifer-recharge expertise.	Test deficit-irrigation regimes and train engineers in precision scheduling.
Delphy & The Salt Doctors	Practical irrigation and fertigation advisory.	Optimise on-farm irrigation routines and nutrient management based on salinity diagnostics.

Large-Scale Drainage and Coastal Works

Company / Organization	Strengths	Possible Role in Egypt
Witteveen+Bos	Engineering of drainage and water-control structures.	Design controlled-drainage networks and supervise rehabilitation of MWRI’s Delta systems.
Boskalis	Marine engineering and dredging.	Construct salinity-barrier works and maintain coastal outlets; contribute to Delta protection projects.
Deltares & The Salt Doctors	Integration of modelling with field diagnostics.	Combine national-scale modelling with site-specific drainage solutions for saline hotspots.

Cross-Cutting Cooperation Platforms

Mechanism	Description	Lead Dutch Partners	Egyptian Partners
National Salinity Observatory	Integrated data hub linking satellite, groundwater, and socio-economic data.	Deltares, Acacia Water, The Salt Doctors, WUR	MWRI, MALR, EPADP
Salinity-Smart Farm Hubs	Demonstration farms for adaptive irrigation, compost use, and tolerant crops.	Delphy, The Salt Doctors, Rijk Zwaan, Enza Zaden	ARC, IFAD, ASAP programme
Controlled-Drainage Rehabilitation	Upgrading of tile-drain systems and drainage reuse schemes.	Witteveen+Bos, Acacia Water	MWRI Drainage Authority
Coastal & Drainage Outlet Protection	Nature-based ICZM measures to reduce seawater intrusion.	Boskalis, Deltares	MWRI, EEAA

Seed & Knowledge Exchange Network	Annual Egypt–Netherlands “Salt-Smart Agriculture Forum”.	WUR, NWP, seed and potato companies	MALR, private sector, FAO Cairo

Why Dutch Involvement Adds Value

1. Complementary expertise in salinity and delta management

The Netherlands combines globally recognized expertise in saline agriculture, water management, and delta engineering. This knowledge is directly relevant to Egypt’s challenges in managing salinity, sea-level rise, and water scarcity in delta and coastal environments.

2. From knowledge to application

Dutch public and private actors have extensive experience translating research into practical solutions, including salt-tolerant cropping systems, precision irrigation, drainage design, and coastal-zone management. This enables support not only at the research level but also in pilot implementation and scaling.

3. Linking innovation to viable business models

Dutch agribusiness and water-sector companies have experience developing commercially viable solutions in arid and saline contexts. Their involvement can help connect technical innovation to market-ready applications, investment pathways, and service delivery models.

4. Strategic alignment between two delta countries

As delta countries facing climate-related water and salinity pressures, Egypt and the Netherlands share comparable long-term challenges. This creates a strong foundation for mutual learning, joint innovation, and context-sensitive adaptation of solutions.

5. Catalyzing new partnerships and projects

Dutch involvement can act as a catalyst for new pilot projects, public–private partnerships, and knowledge programs that build on Egyptian priorities. Rather than standalone interventions, cooperation can support nationally led initiatives and strengthen local capacities.

5. Recommendations

Building on the situation analysis, stakeholder consultations, bottleneck assessment, and the proposed 2035 roadmap, the following recommendations outline the priority actions required to transition toward a salinity and climate resilient agricultural system. The recommendations are based on according to the five pillars: drainage infrastructure and governance, irrigation modernization and leaching, soil health and integrated agronomy, cropping systems and protected agriculture, and monitoring, data harmonization and policy Integration.

Pillar 1: Drainage Infrastructure and Governance

1. Prioritize the rehabilitation and modernization of subsurface drainage networks, especially in the northern and central Nile Delta where drainage-driven salinity is most severe. This includes replacing collapsed tiles and upgrading collector drains. The Egyptian government has already taken important steps in this area in recent years, and these efforts can be further strengthened by drawing on Dutch expertise.

2. Institutionalize long term operation and maintenance (O&M) responsibilities by clarifying duties between MWRI, EPADP, governorates, and Water User Associations. Establish community-based maintenance units and allocate dedicated O&M budgets.

3. Separate irrigation and drainage canals in locations where cross contamination accelerates salinity buildup.

Pillar 2: Irrigation Modernization and Leaching

1. Integrate planned leaching protocols into all irrigation modernization programs. Drip and sprinkler systems must include explicit leaching fractions tailored to soil type, salinity levels, and water quality.

2. Develop EC based irrigation scheduling supported by low-cost field diagnostics and digital advisory tools.

3. Scale field-level water management practices such as raised beds and laser land leveling to reduce capillary rise and improve leaching efficiency.

Pillar 3: Soil Health and Integrated Agronomy

1. Promote integrated soil health packages by introducing organic matter such as compost, biochar, and chemical soil amendments such as gypsum (where sodicity is an issue), and pH management to improve infiltration and root zone function.
2. Support local compost production systems and quality standards to ensure consistent farmer access to reliable organic amendments.
3. Integrate soil health requirements into extension curricula, farmer field schools, and demonstration hubs, ensuring packages are applied together rather than as isolated measures.

Pillar 4: Cropping Systems & Protected Agriculture

1. Strengthen national programs for breeding and introducing salt tolerant varieties, including vegetables, cereals, forage crops, and halophytes, through partnerships between ARC, private breeders, and international stakeholders.
2. Promote protected agriculture and soilless systems such low tech hydroponics systems in regions where soil-based production is becoming increasingly constrained by salinity.
3. Implement crop zoning and land use adaptation plans in coastal and structurally saline environments where remediation is technically unfeasible.

Pillar 5: Monitoring, Data Harmonization and Policy Integration

1. Establish a National Salinity Observatory to harmonize soil EC, groundwater depth, drainage performance, remote-sensing indicators, and salinity-risk maps.

2. Develop standardized national salinity diagnostics based on the four salinization mechanisms to guide intervention selection, budgeting, and performance evaluation.

3. Integrate salinity into coastal-zone management, irrigation-district planning, agricultural zoning, and climate-adaptation policies.

4. Strengthen agricultural extension services by embedding **salinity-smart training modules** and continuous professional development.

Further Recommendations:

Based on the literature review and stakeholder consultations, additional ideas emerged that can further strengthen Egypt’s response to salinity:

1. Design financial incentives and blended finance instruments that reward adoption of integrated salinity-smart packages, rather than single technologies.

2. Enable public–private partnerships for drainage rehabilitation, protected agriculture, water-quality monitoring services, and salt-tolerant seed systems.

3. Promote governorate-level coordination platforms to align MWRI, MALR, EPADP, research institutions, and private stakeholders around salinity specific management approaches and also includes any previous and current projects carried out in this field.

6. Conclusion

Salinity is one of the most significant and rapidly increasing threats to Egypt's agricultural productivity, food security, and water sustainability. It is not a single, uniform problem; it is a systemic challenge shaped by four distinct salinization mechanisms: irrigation-driven, drainage and groundwater driven, coastal/climate-driven, and primary (geogenic) salinity. Each mechanism interacts differently with Egypt's hydrology, soils, climate, and farming systems, and therefore requires differentiated intervention packages rather than generic solutions.

Over decades, Egypt has accumulated extensive technical experience, numerous pilot projects, and significant institutional knowledge. Also, scientific research into salinity and effective measures to counter its negative effects is a strong field receiving global attention. Yet, salinity-smart agriculture has not become the norm in Egypt yet. This is largely due to fragmented interventions, weak coordination, insufficient monitoring, and the limited integration of salinity considerations into irrigation modernization, drainage management, land-use planning, and agricultural extension.

This report demonstrates that Egypt needs more:

- Aligning interventions with the correct salinization mechanism.
- Integrating irrigation, drainage, soil health, and cropping into coherent packages.
- Embedding monitoring, learning, and diagnostics into routine decision-making.
- Linking scalable solutions to finance, markets, and institutional incentives.

The 2035 Salinity Roadmap provides a practical pathway toward this transition. By 2035, Egypt can achieve an agricultural system where:

- Salinity risks are routinely diagnosed and monitored.
- Farmers apply integrated salinity-smart packages suited to their local mechanism.
- Drainage systems are functional, maintained, and institutionally anchored.
- Protected agriculture and soil-decoupled systems support high-value production.

- Coastal salinity is addressed through long-term adaptation and integrated planning.
- Salinity management is fully embedded in regulations, extension services, and national investment decisions.

The Netherlands offers a unique and globally recognized portfolio of solutions that directly address Egypt's salinity challenge. With world leading expertise in saline agriculture, delta water management, drainage engineering, and climate-resilient land use, Dutch institutions and companies bring decades of hands-on experience successfully managing salinity in some of the most complex delta environments worldwide. This experience spans subsurface drainage design and rehabilitation, groundwater and seawater intrusion modelling, controlled drainage systems, precision irrigation, protected agriculture, saline-water treatment, and the development of salt-tolerant crop varieties for areas that align directly with Egypt's current needs. Equally important, the Dutch approach emphasizes data-driven decision support tools, multi-stakeholder coordination, and the translation of scientific diagnostics into scalable, commercially viable field solutions. Together, these strengths make Dutch involvement uniquely positioned to support the implementation of Egypt's 2035 Salinity Roadmap and accelerate the national transition toward salinity-smart, climate-resilient agriculture.

Finally, achieving this vision requires continued leadership from Egyptian institutions, coordinated support from development partners, and strong engagement from the private sector. As two delta nations facing similar water climate challenges, Egypt and the Netherlands are natural partners in this effort. Through joint learning, adaptive experimentation, and sustained collaboration, Egypt and Netherlands can build a resilient, climate and water-smart agricultural landscape that protects livelihoods, enhances food security, and safeguards natural resources for future generations.

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