Background information salinity in Egypt

In short:

- Egypt's salinity problems are mainly caused by irrigation, shallow groundwater and seawater intrusion.
- The main soil type in the delta is heavy clayey to clay. This soil type is commonly drained in the delta, but irrigation with (high) saline water could pose extra challenges with soil structure and drainage. This needs to be investigated further before large scale implementation of "saline irrigation" can take place.
- Locally, more sandy and loamy soils occur in the delta and in general more sandy soil is found on the edges of the delta and in the desert. Possibly these areas have higher potential (than the clay soils) for the implementation of irrigation with saline water.
- There seem to be vast amounts of moderate saline water, both drainage water from irrigation as well as shallow groundwater, that are not utilized at present. A sustainable use of this water (from the perspective of sustainable soil use, water use, and crop productivity) could potentially relieve the pressure on fresh water in Egypt.
- Areas with a shallow groundwater table (1-2 meters) can be the most promising areas for the implementation of saline agriculture. In these areas the leaching fraction of the irrigation water could possibly flow back to the groundwater and be reused for irrigation again. This can be a low-tech and affordable solution to control drainage and the rootzone salinity levels.
- Around 30-40% of the land in the Nile Delta is salt affected. The soils with moderate salinity levels (4-8 dS/m) have the best potential for the implementation of salt tolerant crops.

General characteristics Egypt

According to Mohamed (2016) there are three main factors that cause salinization in the Nile Delta Egypt: irrigation water, shallow groundwater (and waterlogging), and seawater intrusion. The Nile River and its irrigation canals work in the Nile valley as both irrigation and drainage canals at the same time, but the Nile Delta is covered with a good net of drainage canals that collect about 15 billion m^3 per year of which 10 billion m^3 is reused in irrigation (Mohamed, 2016).

Based on FAO (2005) the following can be said about some general aspects and salinity in the Nile delta. "The climate in Egypt is characterized by its aridity, average annual rainfall (from October to May) ranges from 190 mm along the Mediterranean coast to 20-50 mm in the south, annual potential evapotranspiration being about 1400 mm in the coastal zones and increasing towards the south. About 2 million hectares of arable land is irrigated in the Nile delta. One of the problems of the Nile Delta was salinity affecting its clay-textured alluvial soils. However, after installing subsurface drainage system on 90% of irrigated lands control the saline groundwater, most of the soils of the delta are non-saline. However, approaching the coast and lakes, soil salinity increases because of the effect of the shallow saline groundwater and seepage of brackish water from the sea and lakes through more permeable soils. Tests of the drainage water reuse strategies have yielded reasonable results in terms of soil salinity and crop yields. However, as local soil salinity levels might be high, especially in tail end areas where irrigation water is inadequate and groundwater salinity is high, monitoring of soil and water salinity is required. A central issue is how much of the annual drainage discharge released into the Mediterranean Sea and the coastal lakes can be reused."

This text from FAO (2005) seems to imply that the majority of the salinity issues in the delta occur close to the Mediterranean Sea and saline lakes. Although the soil texture is "clay-textured", drainage did seem to work well to leach the majority of the salts. According to Mohamed (2016), the Nile Delta is, for 93%, made up from old dark lands of alluvial soils that have a texture which ranges from heavy

clayey to clay. This implies that leaching may be difficult, but the extent of the drainage canals do show that it is possible to drain this soil type. In general, on the edges of the delta and in the desert, the soils are more sandy. This could imply that the ideal soil type for using saline irrigation water are more on the edges of the delta, or where there is locally more sandy, loamy soil inside the delta, or in the desert. So, the overall soil type in the delta can be suitable for irrigation with moderate saline water, in combination with drainage and leaching. But the soil type (heavy clayey to clay) can be problematic in combination with salts, so extra attention has to be given to this before large scale implementation can be considered. The problem of salts and clay soils consist of the fact that sodium can replace calcium in the cation clay-humus complex and when this happens the soil structure "collapses". The clay particles become more mobile and can block the pores in the soils, resulting in compact and potentially waterlogged soils (among others). This must be prevented at all costs.
Also, there seems to be vast amounts of saline drainage water that is not utilized at present. If a form of saline agriculture can be developed that makes use of this saline drainage water then this can have a major impact in Egypt. Also, there are vast amounts of saline groundwater in Egypt. The extent (both the area affected and salinity concentration) seem to be somewhat variable, most likely caused by droughts (Nile water flow) and over-extraction through wells for irrigation (Al-Agha *et al*., 2015) and this is illustrated in the figure below (figure 1). Here, the salinity is classified as ppm, with the yellow area marked as non-saline (<1000 ppm, or 1.6 dS/m (based on EU calculation of 1000 ppm/640=dS/m), the blue area is moderately saline (1000-3000 ppm, or 1.6-4.7 dS/m) and the purple area is classified as high saline (>3000 ppm, >4.7 dS/m). So, besides the potential reuse of saline drainage water there are also vast areas with moderate and (high) saline groundwater, which potentially can be used for irrigation, in combination with salt tolerant crops.

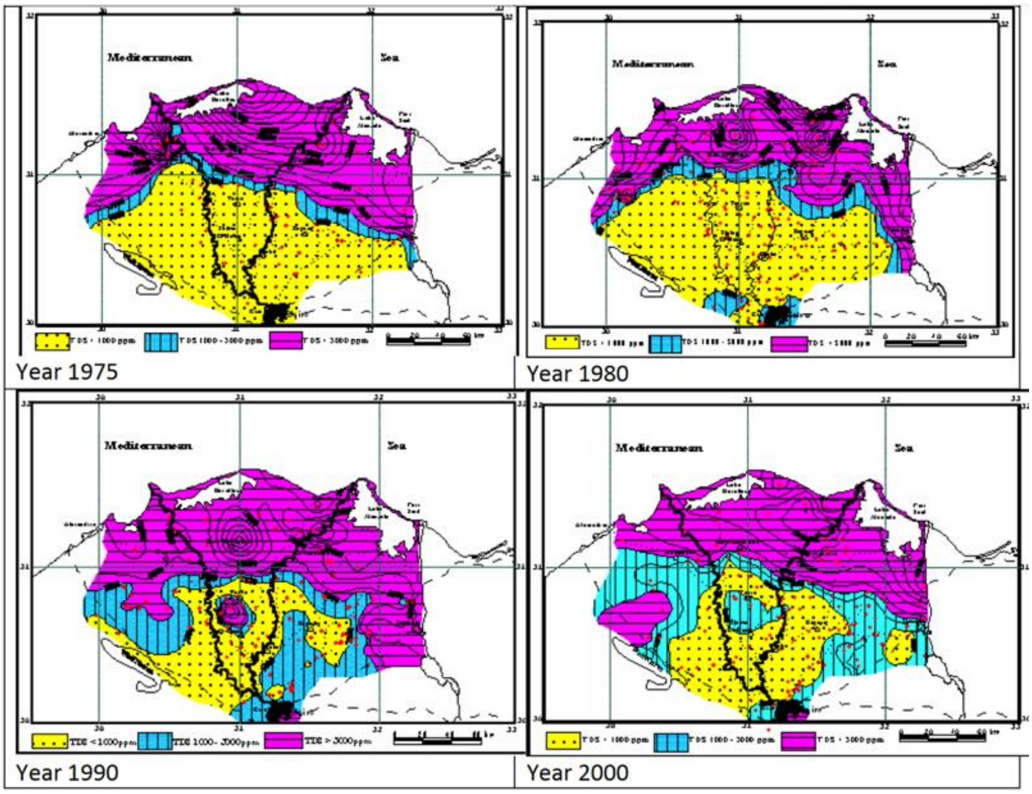

Figure 1. Groundwater salinity levels in the years 1975, 1980, 1990 and 2000 (source: Al-Agha et al., 2015). The yellow marked areas represent a salinity level <1000 ppm (appr. 1.6 dS/m), blue represents 1000-3000 ppm (appr. 1.6-4.7 dS/m) and purple represent >3000 ppm (> 4,7 dS/m).

When irrigating with saline water, leaching is required to control rootzone salinity and prevent salt accumulation. Leaching takes place when the amount of (irrigation) water in the soil is beyond the water holding capacity of the soil. Leaching is relatively easy in coarse textured soils like sand and sandy loam, and it is slow and/or difficult in heavy clay soils. Also, the leaching fraction (the part of water that is leached below the rootzone) should not cause extra salinization or other problems to the deeper soil layers, aquifers or lower lying areas. This can be controlled by, for instance, installing drainage pipes. Another possibility is to select areas with shallow saline groundwater, where the leaching fraction can be allowed to flow to the groundwater. If the saline groundwater itself can be the source of irrigation water, and the leaching fraction returns to the groundwater, then a sort of closed water loop (there is always water loss due to evapotranspiration) is created without expensive measures to control drainage. So, areas with shallow, saline groundwater can be of extra interest for the implementation of saline agriculture. Looking at the map of the depth to the groundwater (figure 2: source: Al-Agha *et al*., 2015) it can be seen that the area directly north of Cairo, and the coastal area, show a depth of 1-5 meters to the groundwater and the majority of the coastal area shows a groundwater depth of 1-2 meters. Especially with this latter groundwater depth it should be feasible to leach the required part of the irrigation water directly back to the groundwater. If the groundwater levels are actually too shallow, then possibly the use of salt tolerant trees can lower the level of the groundwater to the required depth.

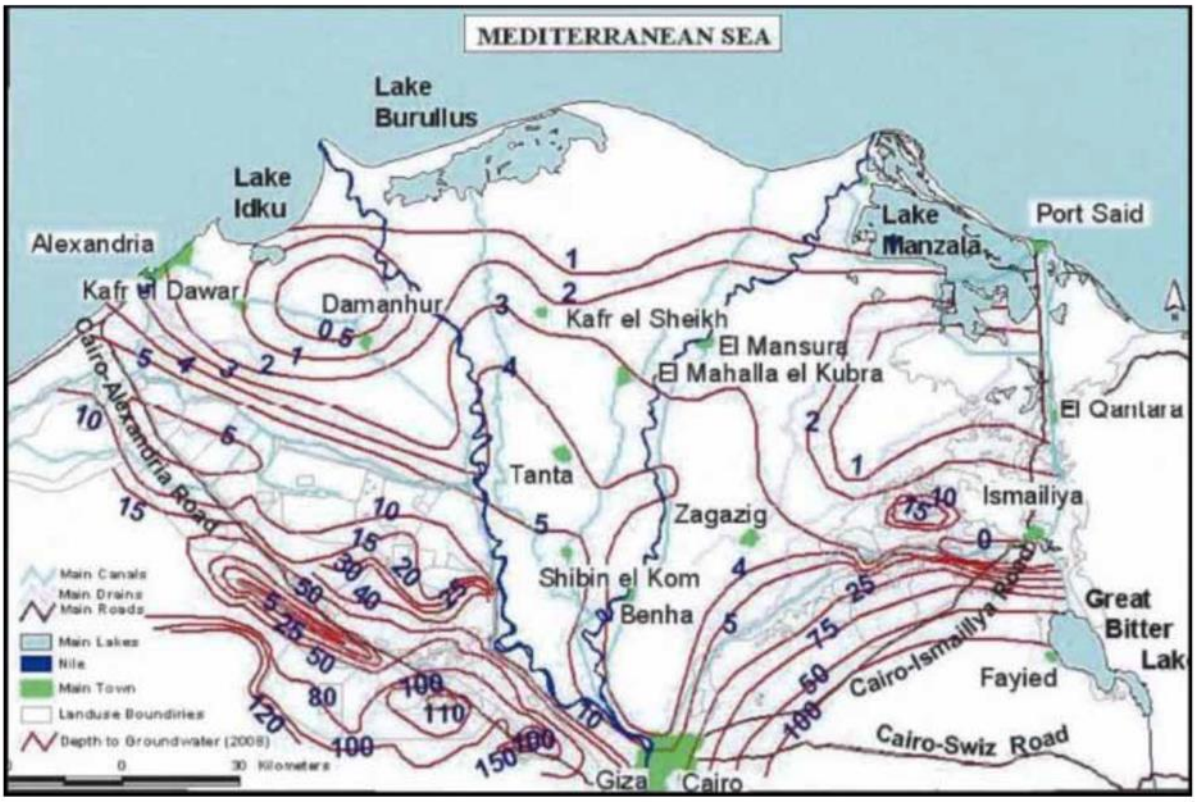

Figure 2. Depth to groundwater of the Nile Delta region in 2008 (Al-Agha et al., 2015).

Also, there is data available of the salt concentrations of the soil (see figure 3). Based on the two sources in figure 3, there seems to be vast areas of moderate saline soils (4-8 dS/m, ECe). Based on the experience of The Salt Doctors there are several crop varieties of conventional crops that can still produce high yields at these salinity levels. So, the areas that show these moderate salinity levels are most suitable for the introduction of the salt tolerant varieties of different conventional crops (see table 3). In the areas with high saline conditions (8-16 dS/m) the options are more limited, but this depends on the actual salinity levels (around 8 dS/m many crops can be selected, at 16 dS/m most crops will not produce a viable yield for the farmers (see table 1). Based on the images in figure 3 it appears that 30-40% of the land in the Nile Delta is salt affected.

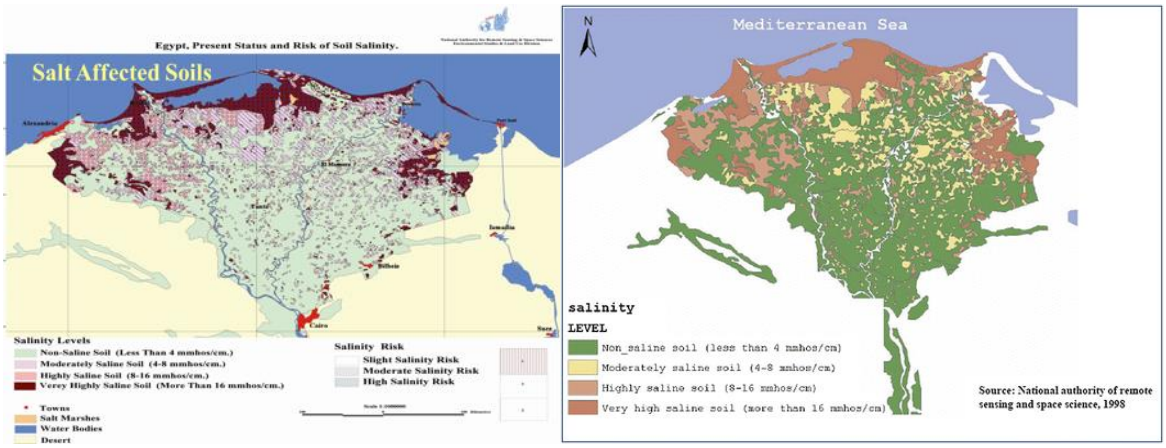

Figure 3. The extent of salt affected soils in the Nile Delta. Image left taken from CGIAR (salinity.agwaterconsult.com/?bio=16), image right taken from Mohamed (2016). The areas with moderate salinity levels (4-8 dS/m) have the best potential for several conventional crops.

Table 1. General salinity classification for soil and the assumed effect on crop growth.

Soil salinity class	EC (in dS/m)	Effect on crop plants
Non-saline	0 - 2	Salinity effects negligible
Slightly saline	2 - 4	Yields of sensitive crops may be restricted
Moderately saline	4 - 8	Yields of many crops are restricted
Strongly saline	8 - 16	Only tolerant crops yield satisfactorily
Very strongly saline	> 16	Only a few very tolerant crops yield satisfactorily

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Literature

Al-Agha DE, Closas A, Molle F. 2015. Survey of groundwater use in the central part of the Nile Delta. Activity report (draft). Water and salt management in the Nile Delta: report No. 6

FAO, 2005. Irrigation in Africa in figures: AQUASTAT Survey.

Mohamed NN. 2016. Land degradation in the Nile Delta. In: Negm A. (eds) The Nile Delta. The handbook of Environmental Chemistry, vol 55. Springer, Cham.

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