CONSULTANCY REPORT ON THE ABADAN PROJECT OF ABVARZAN Co., IRAN

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Table of contents

In the text, recommendations are written in italics.

1. Introduction

The Abadan Project of Abvarzan involves the improvement of 3 pilot areas in the date palm belt along the Arvand River in Iran. The average annual rainfall in the area is 170 mm and occurs mainly in winter. To compensate the scarcity of water the palm trees are irrigated.

Of old, the irrigation of the trees occurs by a system of tidal canals (figure 1), from which river water infiltrates into the soil at high tide. The trees are able to grow on the infiltrated water.

The palm tree belt stretches along the Arvand River over a distance of about 40 km and is bounded in the interior by a road. The width of the belt varies from 2 to 6 km, and on average it is 4 km. Figure 1 shows that the width is greater in the concave parts of the river bends and smaller in the convex parts. The convex parts probably have higher levees and topography.

The total area of the belt is about 16000 ha. A large part of the tree area is abandoned, and the remaining part is used to varying degrees of intensity. The tree spacing is 6x6 m. There are about 300 trees per ha. The maximum yield is about 200 kg/tree and 60 t/ha. Present yields are much less. In the last decades, the production of dates has declined and the pilot areas serve to find a way to boost the production.

The pilot areas of about 50 ha each are situated in the upstream part, the middle part, and the lower part of the belt. The area in the upper part is found in unit KO3 of a newly established irrigation system, the middle area is in unit KQ2 and the lower part in KQ7. The KO3 pilot area has been defined a month ago, and the KQ2 and KQ7 pilot areas a week ago. The information about the last two pilot areas is still scanty.

Each unit has a pumping station with a capacity of 1.5 m3/s to provide irrigation water to about 700 ha (about 2.1 l/s per ha, almost 20 mm/day). The pumped water is led through a network of underground pipes ending in outlets. There are 100 outlets per unit so that each outlet serves 7 ha. The irrigation channels from the outlets to the palm fields have to be developed by the farmers.

The new irrigation systems in units KQ2 and KQ7 are not yet ready. The system in unit KO3 has yet to be put into operation.

In the upper part of the belt the tidal water hardly ever inundates the land. The farmers do not desire to close the tidal canals and to switch over completely to the new irrigation system.

Some tidal canals have been extended beyond the road and a row of new palm trees was planted at each side of it. The farmers are able to leach and reclaim salty land.

Occasionally water is pumped from the tidal canals to irrigate second crops (vegetables) under the palm trees. Some farmers also use pumped water to leach the soil and maintain a favorable salt balance in the soil around the trees. This pumping may be replaced by irrigation from the new system.

In the lower part the land is more frequently flooded and the water is salty. The tidal canals are embanked and houses are built on mounds. Here there may be the desire to close the traditional tidal canal system and to change over completely to the new system.

In the middle part there is a transition situation. It will be the most difficult part to devise an optimal water management system for.

Figure 1. Satellite image of palm tree belts on Abadan Island along Arvand and Bahmanshir Rivers showing approximate location of experimental and study Areas KO3, KQ2, and KQ7

2. Activities of Abvarzan undertaken so far

The Water & Power Authority (WPA) of Khuzestan Province entrusted the project to Abvarzan in July 2004. Since then the following activities were undertaken.

1. - A report is being prepared describing the present situation, including the conditions of agriculture, soils and irrigation. Additional information is collected from older people in the region.

2. - A date palm production survey was started. For this 100 palm trees were selected based on a square grid system, drawn on a map on scale 1:2000, and a random selection of trees within the squares. The size of the grid squares is 500x500m, each square occupying 25 ha. The area of the date palm belt is about 15000 ha. Hence there are about 600 squares. Of these, 100 sample squares were selected.

Within the selected squares, the tree selection was done in office at random and coordinates of the tree were determined. In the field the selected trees were identified using GPS. The date yields of each tree are measured. Tree variety, age, height and other particulars are noted. Soil salinity and depth of the ground water table near the trees still have to be measured. The soil salinity will be measured in 5 places around each tree at about 30 cm depth to assess the variation.

In the KO3 pilot area and additional 15 trees have been selected for surveying. EC values of soil samples are determined from a 1:2 soil solution (2 g water per g of oven-dry soil). The water can be taken from the tap and has an EC value ECw=2.2 dS/m. If mineral water is used the ECw=0.4 dS/m.

After applying an amount of water with double the weight of the oven-dry soil (e.g. 200 g water on 100 g soil) it is recommended to let the suspension rest for at least 1 hour so that the lumps of soil will become thoroughly moist and can be molded with a spoon without difficulty. After stirring the suspension, let it rest again for at last one hour so that the soil particles settle on the bottom of the container in which the suspension was made. Thereafter, pour the water into a glass for the EC measurement.

To relate the EC1:2 value to the ECe of a saturation extract one can use the expression ECe = 4.5 (EC1:2 – ECw) = 4.5 (EC1:2 – 2.2). The error will be < 10%

The soil salinity data presented so far did not reveal a systematic difference between the soil salinity at different depths up to 1 m. *However, to remove any doubts about the distribution of salinity with depth, the soil samples may be taken at 30 and 60 cm depth.*

It is recommended to plot the existing data of soil salinity at different depth against each other (for example EC at 30 cm against EC at 60 cm) and in the same graph draw the line for $EC_{30}=EC_{60}$ *to assess the systematic difference between the salinity of the layers.*

If it becomes clear from the analysis that there is no systematic difference between the two values, the soil sampling at 60 cm may be dropped.

3. - Surveying is done in 7 cross-sections across (from the river and away) to determine topographic and ground water levels. This survey serves to assess the presence of levees near the river and the geo-hydrologic role of the salty depression in the center of Abadan Island between Arvand and Bahmanshir rivers.

4. - In the KO3 pilot area the layout of the traditional tidal channels, ditches and field channels is being surveyed, as well as the position of the turnouts (outlets) of the new irrigation system. A similar survey will be undertaken in the KQ2 and KQ7 pilot areas.

5. - Available data on discharge tidal movements, EC, and pH of Arvand River are being collected.

It is recommended to measure the tidal wave during a complete cycle at the entrance to one tidal canal in each of the pilot areas. The cycle can be selected during a period of neap tide, normal tide and spring tide while the Arvand River has low discharge (at the end of summer), high discharge (after a rainy period in the Zagros Mountains), and normal discharge. The total the number of tidal cycles to be measured is 3(pilot areas) x 3(tidal situations) x 3(river stages) = 27

At the same time the EC of the water is to be measured. The pH is less important as there are no alkalinity problems.

6. - Satellite images are being collected for the pre-war, war, and post-war situation.
It is recommended to obtain air photos also.

3. Socio-economic conditions

Many palm gardens have been abandoned. Many, but not all, of the abandoned palm tree gardens were damaged during the occupation by Iraq a decade ago.

It is recommended to collect information on the reasons why the abandoned gardens are not restored.

It could be that the property is not large enough or the production not high enough to generate sufficient income to maintain a family so that the owner moved to somewhere else in search of better income opportunities. It could also be that the price of dates on the market is not enough to justify investments in reclamation of deteriorated palm tree gardens.

It is recommended that in the pilot areas information will be collected about the properties, ownerships and addresses of the owners. Owners of abandoned or neglected palm tree gardens or their acquaintances may be asked for the reasons of neglect.

Technical reclamation measures alone are sometimes not sufficient to stimulate the farmers to attend more intensively to the gardens. There may be socio-economic problems, like getting agreeable long-term loans for investment, which need also be solved.

4. Tidal fluctuation in Arvand River and tidal canals

Tidal fluctuations in river mouths are greatest near the shore and become gradually smaller upstream. In Arvand River, at the mouth in the KQ area, the tidal fluctuation varies between 1.7 and 1.9 m (say 1.8 m). Upstream, at the KO area, the fluctuation ranges from 1.5 to 1.7 m (say 1.6 m), due to the attenuation of the tidal wave in upstream direction (figure 2).

See also the simulations with DuFlow of tidal levels on page 19.

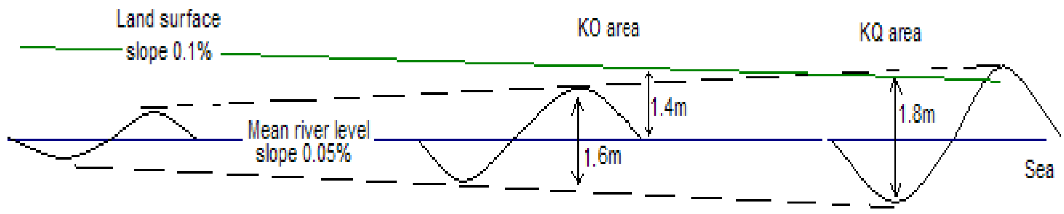

Figure 2. Attenuation (flattening) of the tidal fluctuation in the river in upstream (inland) direction from the sea

In winter and spring, the river discharge is higher, the slope of the water level is steeper and the height of the water level is more (figure 3). Although, at high discharge, the attenuation of the tidal wave is more pronounced, the higher river level compensates this fully.

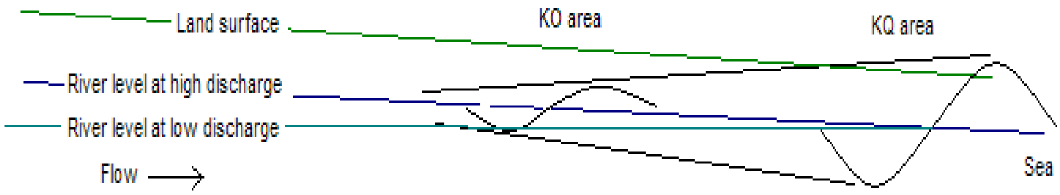

Figure 3. Stronger attenuation of the tidal wave at high discharge compensated by by higher river level (compare with figure 2).

The time of inflow into the tidal canals reduces in upstream direction because the tidal wave is attenuated (flattened) and the intake level is higher (figure 4).

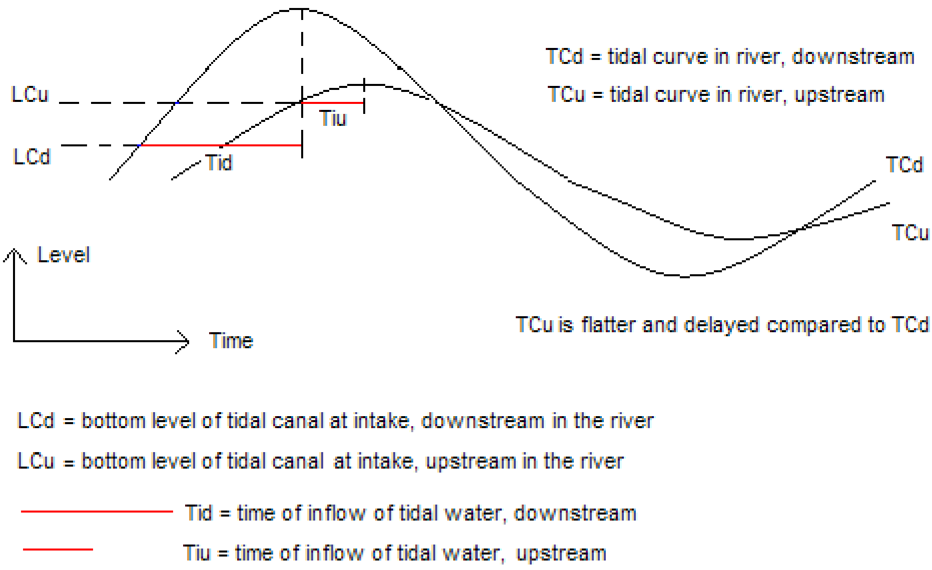

Figure 4. Propagation, attenuation (flattening), retardation (delay) of tidal waves in a river and time of inflow in tidal canals depending on their bottom level and position along the river

The tidal fluctuation inside the tidal canals reduces further, because their cross-section is smaller than that of the river (figure 5).

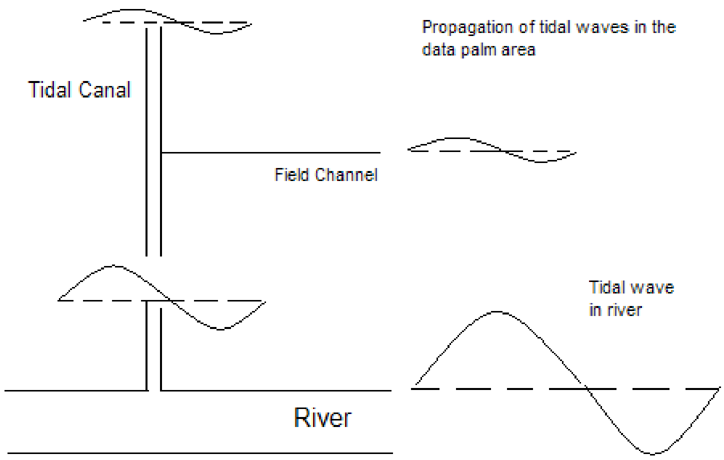

Figure 5. Propagation and attenuation of tidal waves in tidal canals

In the lower part of the palm belt, at the KQ area, the tidal canals are relatively wide and deep. Even in 6 km long canals, the reduction of the tidal amplitude is limited, and at the inland end of the canals, the fluctuation may still be 1.3 to 1.5 m.

In the upstream part, at the KO area, the tidal canals are shorter, shallower and narrower. Hence, the tidal fluctuation at a distance of 2 km from the river would be 1.1 to 1.3 m, provided that the bottom level of the canal is at low tidal level. In reality, the bottom level is higher, so that the amplitude is smaller, possibly 0.5 to 0.6 m. In poorly maintained canals, the fluctuation is further reduced to 0.2 or 0.3 m. This would hardly be enough to provide sufficient infiltration of water into the soil for palm tree cultivation.

For recommendations about observing the tidal waves see section 2.

5. Salinity of Arvand River

According to the Anhar Janoob report of December 2001 (Smedema and Cavelaars), the salinity of the Arvand river has increased considerably in the last decades due to higher salt content of the incoming river water, reduced flow owing to increased water abstractions and consequently an intruding salt water wedge from the sea. In the upstream part of the date palm belt, in the KO area, the river water has and EC value between 2 and 3 dS/m, whereas in the downstream part (the KQ area) the EC ranges between 7 and 10 dS/m, but occasionally the value may rise to over 15 dS/m during short periods in mid summer.

Recent measurements made by Abvarzan have shown the EC value of the river water to be 2.2 dS/m. This holds for the end of the summer period, when the river discharge is minimum. In winter, at higher river discharges, the EC value will probably be less.

The salinity of the river water in the KO area is acceptable and it will probably not higher than the salinity of the irrigation water from the pipe line system.

Further downstream, however, the salinity of the river water may be too high for sustainable tidal irrigation. Yet, this water can be used for the initial leaching of very salty soils. For example, a soil with a salinity corresponding to ECe=50 dS/m can be leached initially with river water having a salinity corresponding to ECe=10 dS/m.

However, for sustainable log-term irrigation in the downstream areas it would be better to use the water from the pipeline system.

For recommendations about EC measurements of the water in the Arvand River see section 2.

6. Soil structure and permeability

In tidal lowlands the clay soils are permanently saturated at some depth. In the saturated zone there is absence of air and oxygen and no structural development occurs. The permeability of the soil is very low at this depth.

To the contrary, in the upper part of the soil, above mean sea level, one finds cracks, root holes and other biological pores (figure 6). In such conditions the soil is well aerated and has a high hydraulic conductivity. In the KO area the depth of the developed topsoil is more than 1 m, but in the KQ area it is less.

Measurement of the hydraulic conductivity below the water table using the auger hole method does not permit to draw a conclusion about the permeability above the water table, but it is probably much higher than the auger hole measurements would suggest.

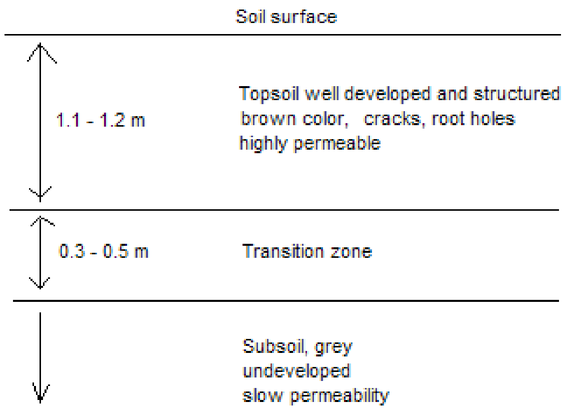

Figure 6. Soil structure with depth in tidal lowlands. The figure shows the conditions in the KO area. Nearer to the sea, in the KQ area, the depth of the developed topsoil is less.

The topsoil over 1 m depth is able to transmit at least 10 mm of water per day (100 m3/day per ha) for the consumptive use of date palms. Hence it should be able to perform the drainage during of a leaching program or of the deep percolation losses arising from excess irrigation water due to lower irrigation efficiency without any difficulty.

7. Soil Salinity

Not much is known about the soil salinity in the whole date palm belt southeast of Abadan. However, some data are available for the KO region from the Anhar Janoob report. ECe values of soil salinity are seldom less than 10 dS/m and mostly more than 20 dS/m. Values higher than 50 dS/m are found in the abandoned lands. The soil salinity values are without any doubt too high for a reasonable date production per tree.

It is recommended to effectuate a leaching program in the pilot areas using the water of the new irrigation system to bring the soil salinity down to normal levels.

From the available pH values it can be concluded that it ranges between 7.8 and 8.5. These values are normal and no soil alkalinity/sodicity problem is to be expected.

In the last decade it was found that the classification of saline soils in S-A (Salinity-Alkalinity/Sodicity,) classes is not relevant. Saline soils have by nature a high content of Sodium Chloride (NaCl). By leaching these soils, the Sodium is removed rapidly because the NaCl is highly soluble. After leaching, these soils become normal non-saline and non-alkaline/non-sodic soils.

In fact the letter A in the S-A classification stands for Alkalinity, but it is not determined by pH (the true index for alkalinity) but rather by the Sodium Adsorption Ratio (SAR), which is an indicator of Sodicity rather than Alkalinity. The higher the SAR value the higher the A class. High A-classes are 3 and 4. Highly saline soils (S-class values of 3 and 4) with low Sodicity (e.g. the classes S3-A0, S3-A1, S4-A0, S4-A1, and S4-A2) hardly ever occur.

Saline soils have by nature a high A-class due to the presence of NaCl. So the common S-A classes in saline soils are S3-A3, S4-A3 and S4-A4. Upon reclamation by leaching these saline soils get a better soil structure than before. According to the original theory, a high A-class suggest that the structure of a saline would become worse after leaching without amendments, but this theory was proved to be erroneous.

The true alkalinity/sodicity problem occurs only in non-saline soils when a large amount of Sodium-(bi)Carbonate ($Na2CO3$, $NaHCO3$) is present. These soils have high pH values (pH>9.5) and a poor soil structure. They are difficult to leach and for their reclamation amendments (such as gypsum or pyrite) are required. Alkaline/Sodic soils have not been found in the Abadan Island.

Occasionally one notices shiny, brownish, powdery topsoil. This points to a very saline top layer (EC>50 dS/m) that holds moisture due to the hygroscopic properties of NaCl. This soil can be reclaimed normally by leaching without amendments.

When preparing maps of soil salinity from point observations using the Krieging method it is recommended not to go into extrapolation. Let the iso-salinity lines not b smaller than the smallest observed value and not larger than the highest observed value. In other words, the iso-lines outside the observed range of values should not be shown on the map. It would be better to leave such areas blank. This also holds for the mapping of other soil properties such as pH.

Also it is recommended to take into account the micro variation of soil salinity. This variation will become apparent from the palm tree survey (see section 2) in which 5 soil samples are taken per tree. Therefore it will be necessary to perform a statistical analysis to test whether the results of interpolation using the Krieging or any other technique (linear interpolation is just as good) are acceptable.

8. Land, water, and canal levels in the KO area

In the KO area one uses Tidal Canals (TCs) to bring the water from the river into the land (figure 7). The canals have a spacing varying from 50 to 60 m (sometimes more) and a depth of 0.8 to 1.2 m. The side slopes are very steep indicating a good stability of the soil. The length of the canals in the KO area is typically 1 to 3 km.

The mean land elevation in the KO area varies from 1.3 to 1.5 m (say 1.4 m) above mean sea level (MSL), but lower lands at 1.2 m and higher lands at 1.6 m occur occasionally.

In river plains, the topography is often characterized by the presence of levees near the river. Therefore, the level of the soils near the river may be higher than further away, even though the difference may be small (say less than 1 m). Towards the basin soils in the middle between two rivers, the land level usually drops again.

The topographic characteristics will have to be ascertained from the cross-sectional survey (see section 2.3).

When levees are present, the depth of the tidal canal should be deeper in the more elevated land. This explains that some tidal canals still function well at a distance of 2 to 3 km from the river or more, where the land level is lower than in the levees. But it also explains that in the convex bends of the river the tidal canals are shorter then elsewhere, because the land level gets higher away form the river due to the existence of natural levees.

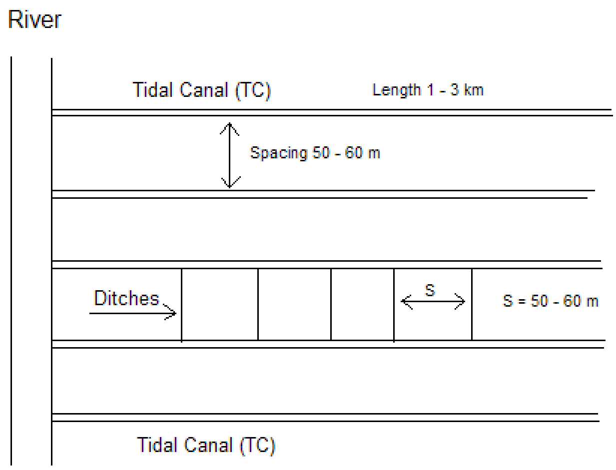

Figure 7. Tidal canals branching off from the river

The mean tidal range in the KO area varies between 1.5 to 1.7 m, say 1.6 m. High tides reach an average height of about 0.8 m above mean river level (MRL) and low tides reach an average level of 0.8 m below MRL. The mean sea level (MSL) may be slightly below MRL here.

The mean land level is 0.5 to 0.7 (say 0.6) m above the mean high tidal level and 2.1 to 2.3 m (say 2.2 m) above average low tidal level.

For a good water transport into the land at high tide the TCs need a water layer of at least 0.5 m thickness, otherwise the propagation of the tidal wave is hampered too much (figure 5). With a land level of 0.6 m above mean high tide (MHT), this means that the bottom of the TCs should be at a depth of 1.1 m below the soil surface or deeper. With a land level of 2.2 m above mean low tide (MLT), this implies that the bottom level will be 1.1 m or less above the mean low tide (MLT).

Some TCs are poorly maintained. They have caved in and are overgrown with reeds and weeds. *When a soil reclamation and leaching program is implemented, it is recommended to reshape and clean these canals to secure a proper drainage function during low tide. The depth must be brought to at least 1.2 m below the soil surface (figure 8). The bottom width may be about 1m.*

In view of the good stability of the soils, the side slopes may be relatively steep, say 1:2 or even 1:3 or more (horizontal : vertical). When after some time some unexpected sloughing of the canals occurs, one may expect the farmers to do to the necessary maintenance.

Not much is known about the current social organization and responsibilities for the maintenance of the tidal canals. *It is recommended to investigate the present organizational structure and to set up water user associations for the maintenance.* Water user organizations will also be required for management of the irrigation water.

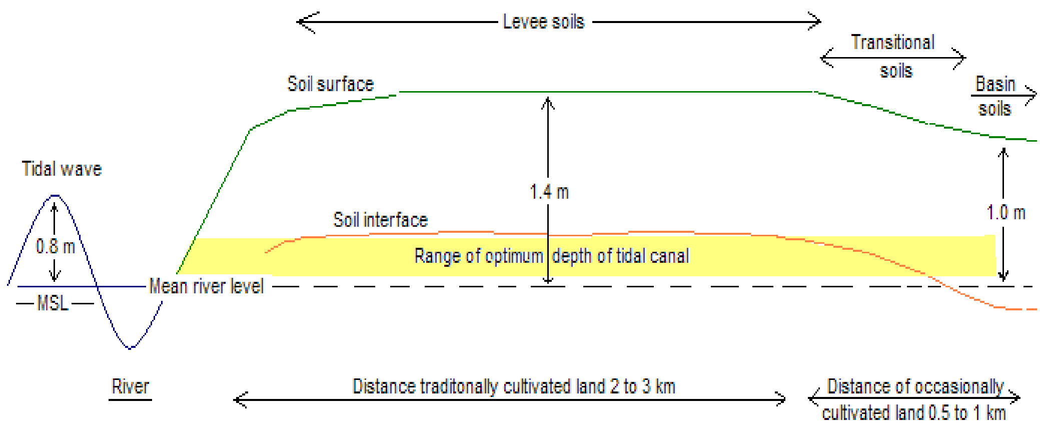

Figure 8. Model of a longitudinal section along a tidal canal and cross-section from the river over the levee into the interior basin area. The soil interface separates the permeable topsoil from the unstructured subsoil. *The indicative measures of the model need to be verified for each tidal canal or group of tidal canals.*

9. Layout of field channels in the KO3 area

There appear to be 3 types of tidal channel layout in the KO3 area.

Type 1 layout consists of lateral ditches (LD) perpendicular to the tidal canal (TC) and connecting two neighboring TCs (figure 9). The field channels (FC) that receive the water from the LDs run parallel to the TCs. The distance between the FCs is about 12 m. The palm trees are planted some 3 m from the center of he FCs and the distance between the trees is 6 m.

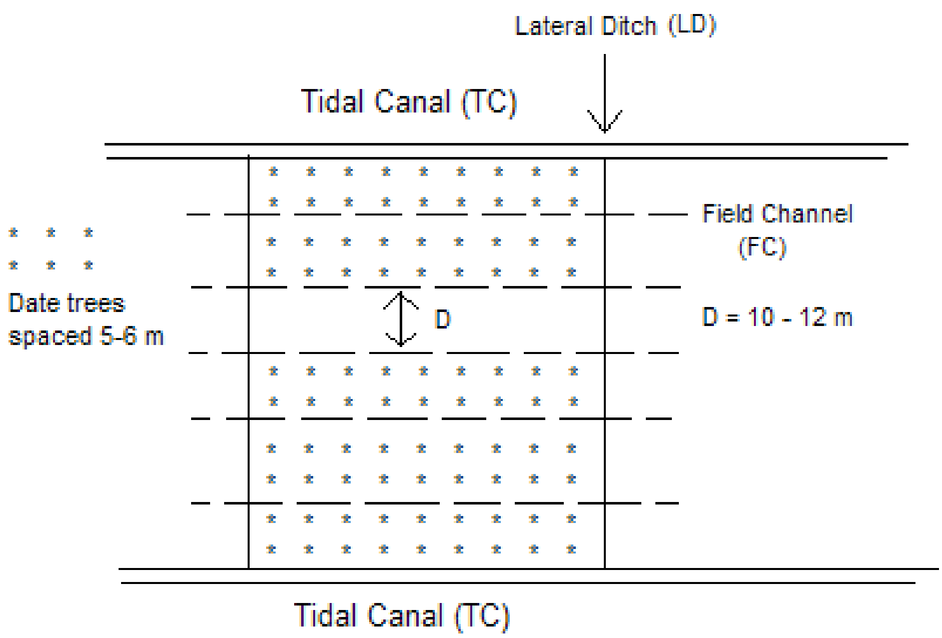

Figure 9. Type 1 layout of tidal irrigation system.

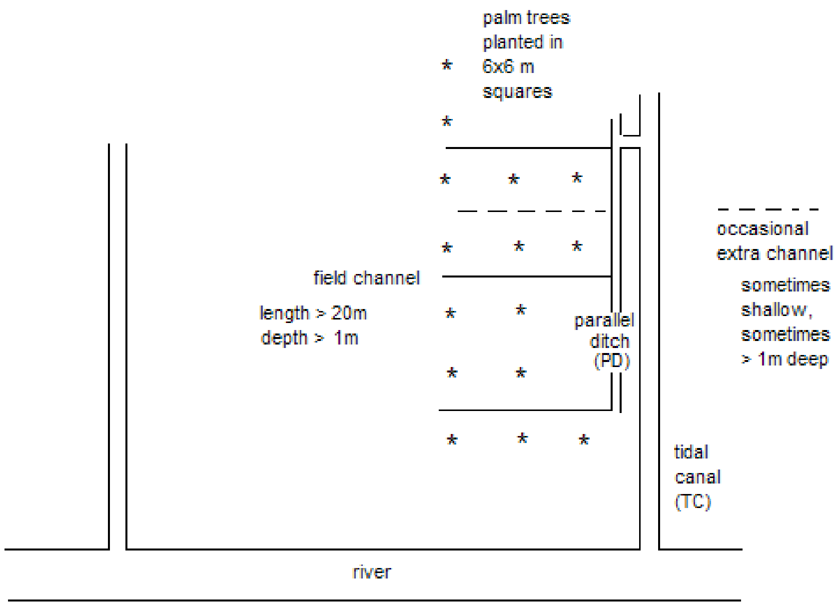

Figure 10. Type 2 layout of tidal irrigation system

The Type 2 layout has a parallel ditch (PD) along the tidal canal (TC) instead of a lateral ditch. The parallel ditch supplies water to field channels (FC) that run perpendicular to the tidal canal instead of parallel as in Type 1 (figure 10).

In abandoned lands, the Type 2 system is suitable for land reclamation and leaching because it gives the opportunity to install a small gate at the junction of the tidal ditch with the tidal canal. *During the reclamation phase this gate must be opened at low tide and closed at high tide for optimal drainage*. When the gate is kept closed at high tide for a longer period of time and the tidal canal system is deep enough (1.2 m or more), this may enhance the development of a good soil structure (see section 6) to a deeper depth so that the root penetration of the palm trees and the drainability of the soil increases. This could promote both the salinity control and the tree production.

In the Type 2 system it is not required that the field channels in the middle between two tidal canals are connected. This facilitates the management of tidal water in smaller units, and the space between the field channels in the middle can be used to position the future irrigation channels of the new irrigation system.

In a water user association, owners of farms in Type 1 systems should have responsibility for the maintenance of both the tidal canals between which his property is situated, because the lateral ditches and field channels are interconnected and receive their from both tidal canals. Owners of farms in Type 2 system would have responsibility of maintenance of only one tidal canal.

In the layout of field channels many variations may be found. As variant intermediate between Type 1 and Type 2 systems like Type 3 (figure 11) also exist.

Abvarzan is presently identifying the actual layout of the tidal irrigation system in pilot area KO3 and we will have to await the results to draw conclusions about the future management of the field channels.

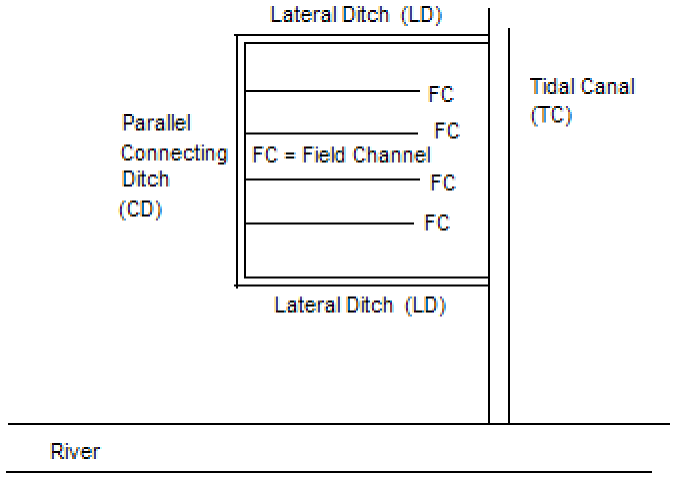

Figure 11. Type 3 layout of tidal irrigation system

10. Layout of the new irrigation system within the KO3 unit

The general layout of irrigation laterals (pipelines) and hydrants (inlets, takeoffs, turnouts) is shown in figure 12.

Each turnout serves a stretch of land of 280x120 m at both sides. It has the capacity to provide 100 l/s during 24 hours, 1 day per week. This amounts roughly to 15 l/s per day or 2.1 l/s per week, corresponding to almost 20 mm/day continuously.

The new irrigation infrastructure may interfere with the traditional infrastructure of the tidal irrigation system. Abvarzan is presently identifying both systems in the pilot area KO3 and we will have to await the outcome to draw conclusions about the integration of both systems.

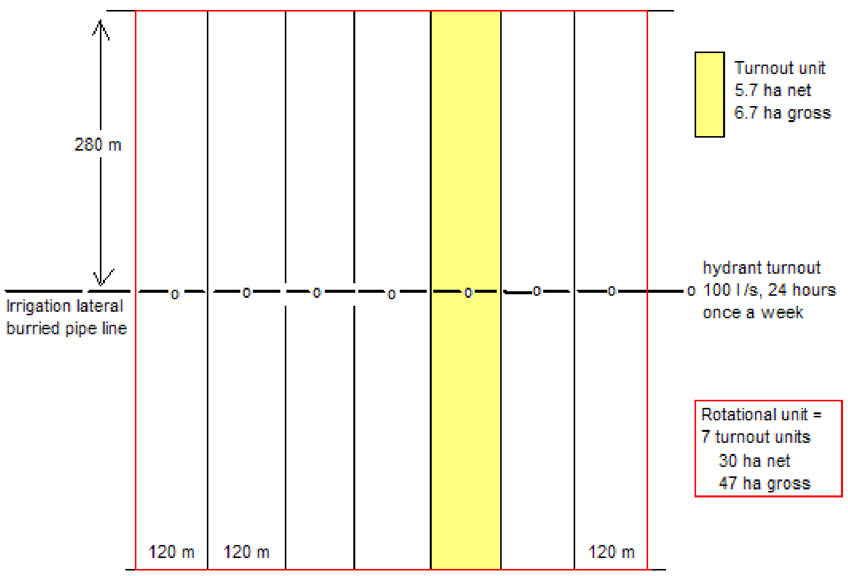

Figure 12. General layout of the new irrigation system within the unit

11. Reclamation, leaching and salinity control program in the KO3 pilot area

From the soil and water salinity data (see section 7) it becomes apparent that the soils need to be leached to remove excess soil salinity. The leaching can be done with the water of the new irrigation system. *Therefore it is important to integrate the traditional tidal irrigation system with the modern irrigation system*. At the same time the tidal canals can serve as drains during low tide to transport the leached salts out of the area. In addition they mark property boundaries.

The tidal canal system, if in good condition (see section 8), has the capacity to provide 10 mm of water per day or more for the consumptive use of the date trees in summer without inducing excessively high water tables. The amount corresponds to 100 m3/ha per day or about 1.1 l/s per ha. Therefore the tidal canal system should be able to fulfill the drainage function without difficulty, because it needs less capacity than for the irrigation function.

During the initial stages of land reclamation, the drainage discharge may be more than 10 mm/day, but the leaching program will not be carried out over the whole area at once but only some fields at a time, so that even then the carrying capacity of the tidal canals will be amply sufficient and no additional drains are required.

One can make a distinction between the reclamation of abandoned land and productive land. In the abandoned land, which is generally more saline, the leaching program is more necessary and more easily done.

In the productive land, one will have to agree with the farmer on the reclamation procedure.

11.1. Initial leaching and reclamation of abandoned land

It is recommended to leach the abandoned land by installing the Type 2 tidal canal system (see section 9 and figure 10) and providing the ditch with a gate for tidal control (figure 14). The gate must be closed at high tide, to prevent tidal water from entering the field, and opened at low tide, to facilitate drainage of the leaching water applied from the new irrigation systems.

If the parallel ditch serves two different farms, one will need also two gates (figure 13).

The field channels can be somewhat shallower than the tidal canals, because they do not have to transmit the tidal wave over a long distance. Their depth may be some 20 cm less, but the minimum depth is 1 m. The bottom width may be between 0.50 and 0.75 m and the side slopes may be 1:2 (hor:ver).

If the irrigation system is not yet operational one can do the leaching also by pumping water from the field ditch. In that case the gate is not required, but one must install an additional pump.

The field units between two field channels may be flooded with 10 to 20 cm of water from the modern irrigation system. To achieve this, the modern irrigation system must be equipped with field irrigation channels so that the water can be taken at the turnout and brought to the field.

To prevent the water from infiltrating unevenly, the land surface must be smoothed.

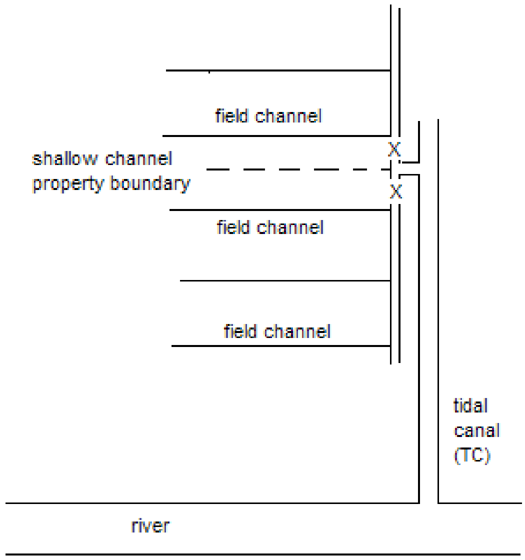

Figure 13. Layout Type 2 with property boundary and two gates

To prevent water from flowing over the field surface and draining directly to the channel or infiltrating in the vicinity of the channel, the field must be subdivided by small bunds of 20 to 30 cm height as shown in figure 13.

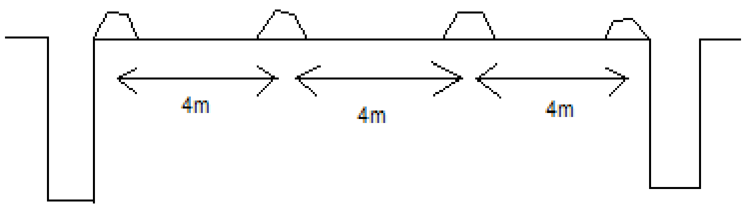

Figure 13. Preparing the field between two field channels for leaching,
providing bunds at regular distances.

After 3 to 5 leaching proceedings, the soil should be sufficiently desalinized to begin cropping. During the leaching process, the salinity of the soil and drainage water must be monitored to determine the optimal number of leaching procedures. During the leaching period the water table may come close to the soil surface without problem.

11.2. Cropping the reclaimed land and maintaining a favorable salt balance

After reclamation it is recommended to plant pilot palm trees in small basins of say 2x2 m connected with each other by small surface channels and connected to the newly constructed irrigation channel by branch channels (figure 14).

Normally the palm trees (spaced at the traditional 6x6 m) can be supplied with water from the tidal irrigation system, and the gate at the connection point between tidal canal and ditch can be left open continuously. However, it is likely that with this practice soil salinity will slowly build up again. Therefore it will be necessary to repeat the leaching procedure (e.g. yearly during winter) using fresh water from the modern canal system and closing the gate in the ditch during high tide.

To this end, one floods the palm basins with a layer of fresh water to a depth of 10 to 20 cm, preferably in winter. Experience and monitoring will learn how often this leaching must be repeated, but it is expected that 2 to 3 leaching procedures are sufficient.

If one uses the new irrigation system to provide water to the plants instead of the traditional tidal system, it is recommended to use flap gates ensuring that no tidal water can come in, but that the drainage water can be evacuated. If sufficient irrigation water can be given once a week, there will probably be no salinity build up any more, as sufficient leaching will occur every week.

In addition to the pilot palm trees one could grow pilot fodder crops (e.g. alfalfa, barley) in extra basins, as shown in figure 14. The location of the extra basins is arbitrary. Also the growing of vegetables in furrows could be experimented.

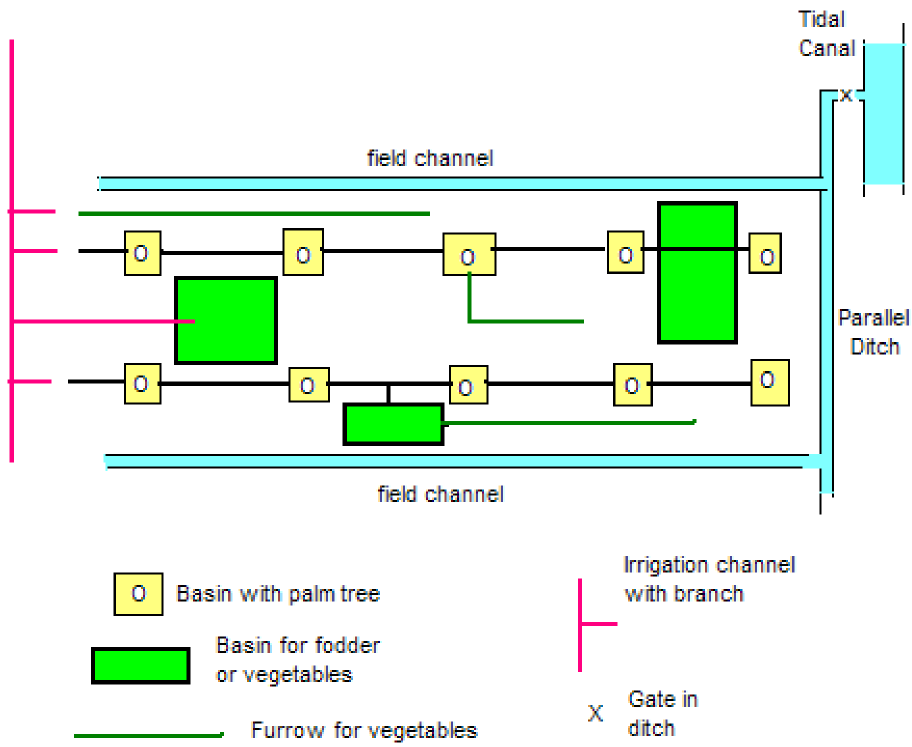

Figure 14. Pilot developments in reclaimed and desalinized abandoned land.

The drawing of figure 14 is schematic only and each field may have a different layout. For example one could crop one complete field with barley for fodder, because barley is salt tolerant. Cows are important in the area and there may be need of fodder crops. Therefore, one could also crop one entire field with alfalfa. This crop develops a deep rooting system and may be useful not only as fodder but also to enhance the soil structure.

11.3. Leaching and reclamation of cultivated land

Due to the presence of existing tidal canal systems and date palm trees it will be more difficult to improve the cultivated farms. It will probably be difficult to practice desalinization by flooding as proposed for the abandoned land, because that would involve too much restructuring of the current land and water management systems.

Yet, ways and means must be found to do so because also here there are salinity problems and it is important to keep the farming population interested in the continuation of date production.

It is recommended to introduce in the cultivated lands similar field irrigation layouts as illustrated before in the abandoned land, such as new irrigation and branch channels, irrigation basins around the palm trees and pilot basins and furrows for the growing of fodder crops and vegetables.

After identifying the exact position of the tidal and modern irrigation infrastructure elements, designs must be made to lead new irrigation channels from the turnout points to each unit of farm land. This will probably entail a large number of flumes to be laid over the numerous tidal channels. The flumes may be made removable. However, if the new irrigation system is not yet operational one can do the leaching also by pumping water from the field channels (see section 11.2).

Having accomplished the integration between old and new irrigation systems, it is recommended to apply ample amounts of irrigation water from the turnouts to the various basins and furrows to achieve the initial leaching of salts from the soil.

The leaching process in the cultivated lands will take probably a longer time than in the abandoned land, because complete flooding will perhaps not be possible and it will be difficult to install gates to exclude the tidal water for some time. The difficulty arises from the feature that many tidal irrigation channels serve more than one property. Yet it should be possible to conclude the leaching program successfully and boost the date production.

12. Observations on the KQ2 area

The KQ2 area lies close to the concave part of a bend in the Arvand river, downstream of the KO3 area. The tidal canals are stretch farther inland than in the KO3 area to a length of 4 to 6 km.

The field levels in KQ2 are probably lower than in the KO3 area, and the presence of a levee may be less pronounced. Therefore, one observes occasionally that tidal ditches and field channels have been provided with bunds of about 30 cm height to prevent water logging on the fields during exceptionally high tides. However, if the flooding occurs only a few times per year in the winter period, the flooding can be helpful in leaching the soil and maintaining a reasonable salt balance.

The salt concentrations of the soils in the KQ2 area may be somewhat less than in the KO3 area.

In the KQ2 area one can observe many abandoned and ill-maintained palm tree gardens. The average production of dates per ha is very low.

Many fields in the KQ2 area are reed-infested. It is said that wild boars dwell in this area. Before starting a reclamation program, it is necessary to clear the fields by mowing the reeds and burning. Thereafter, it is likely that new shoots of reed will come up. Perhaps it will be useful to use the pesticide RoundUp once or twice to eliminate the roots of the reed after the first mowing. Anyway, the fields will have to be cleared of reeds several times before the reeds will be completely eradicated.

Otherwise, the program of measurements, observations, reconstruction and reclamation discussed for the KO3 area is also applicable here, with the exception that it may be recommendable to provide the new tidal canals, ditches and field channels with small bunds with a maximum height of 0.5 m.

In case the water from the pipeline system is not yet available, the leaching of the soils must be done by pumping water from the tidal canals, ditches and field channels.

13. Observations on the KQ7 area

The tidal canals in the KQ7 area are much wider than in the previously discussed areas. The canals have service roads on an embankment. The selected pilot area lies in a strip of land 100 to 200 m wide between to tidal canals. Contrary to the previously discussed areas, the pipeline providing water to the turnouts runs parallel to the tidal canals instead of perpendicular.

The situation of the date palm gardens is desolate. The tree density is very wide and the vast majority of the trees in totally unproductive. Occasionally, farmers are digging new ditches in an effort to bring the few palm trees worth the effort into a higher production. The efforts are clearly haphazard trials.

It is reported that in the KQ7 area there are fields that remain waterlogged for a long time when the flooding by the tidal waves enters the land but cannot be drained due to the presence of embankments and/or irregular topography of the fields with many depressions. Suggestions for solutions of this problem await more detailed information on topography and tidal levels.

The information on the KQ7 area is still so scarce that further conclusions about the KQ7 area must await the outcome of the investigations. One of the decisive parameters will be the quality of the tidal water that may or may not be influenced by intrusion of saline seawater into the Arvand River.

Simulations with Duflow using elementary information of Abadan Island. With more data about topography and river levels (at normal, neap and slack tides, and at normal, high and low river discharge), the simulations can be improved. This is important to establish the optimum depth of tidal ditches.
This is important to establish the optimum depth of tidal ditches. The depth depends on the level of the soil surface and on the tidal level.
The two conditions must be balanced.