ASSESSMENT OF IRRIGATION AND DRAINAGE NETWORK IN QUDS REGION THROUGH WATER TABLE DATA

EVALUATION DU RESEAU D'IRRIGATION ET DE DRAINAGE DANS LA REGION QUDS PAR LES DONNEES DE LA NAPPE PHREATIQUE

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ABSTRACT

Agriculture and animal husbandry were practiced in the Quds region many years ago, generating income for the people. The soils of the region were good and water was available from the Karkheh River. However, incorrect operation of the irrigation network, channel sedimentation and weed growth in the net work, lands were salinized. The problem aggravated due to a lack of underground drainage system and surface water congestion. Besides, there was no access to the modern agriculture machinery and no systematic monitoring of the performance of the irrigation system relating the performace with the limiting water table depth or its safe range. As a result, the value of the system depreciated quickly and efficiency of irrigation was reduced. Water table depth observations revealed that it was generally shallow and varied from as low as 0 m from the ground surface to a maximum of 3.4 m below the ground surface. The deepest water table occurred during October and the shallowest water table of mostly shallower than 1 m occurred in March. During the remaining months, the water table fluctuated within this range.

Key words: *assessment, drainage and irrigation network, water table.*

RESUME

Il y a plusieurs années, l'agriculture et l'élevage d'animaux ont été pratiqués dans la région Quds, produisant le revenu pour le peuple. Les sols de la région étaient fertiles et l'eau était disponibles dans la Rivière Karkheh. Cependant, l'exploitation incorrecte du réseau d'irrigation,

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la sédimentation du canal et la croissance des mauvaises herbes dans le réseau, les terres devenaient salines. Le problème a encore aggravé en raison du manque de système de drainage souterrain et de l'encombrement de l'eau de surface. De plus, il n'y avait aucun accès aux équipements modernes agricoles et aucun contrôle systématique sur la performance du système d'irrigation concernant la profondeur de la nappe phréatique. En conséquence, la valeur du système a déprécié et l'efficience d'irrigation a réduit rapidement. Les observations sur la profondeur de la nappe phréatique ont indiqué qu'elle était peu profonde et a varié de 0 m au niveau de la surface jusqu'à un maximum de 3,4 m au-dessous de la surface de terre. La nappe phréatique la plus profonde est disponible en octobre et la nappe phréatique peu profonde que 1 m en mars. Au cours des mois restants, la nappe phréatique varie entre cette gamme.

Mots clés : *Evaluation, réseau d'irrigation et de drainage, nappe phréatique.*

1. INTRODUCTION

Old irrigation and drainage network of the Quds region has been completed during 1954 -1964 in different phases. Required water for the mentioned network is supplied by the main channel on the right side of Karkheh dam called RBMC. Agricultural and animal husbandry have been traditionally practised in the Quds region and these have been the main source of income to the people of the region. However, due to disregard to the water management aspect, the lands were degraded due to various reasons such as water table rise, soil salinization, weed growth and sedimentation in the irrigation water conveyance net work and lack of drainage facility. After comprehensive study of Azadegan plain lands on the basis of good soil and water potentials, this region along with the Hamidieh region were selected for the construction of irrigation (using water from the Karkheh River) net work and drainage networks in priority. Consequent upon their construction, this region has developed agriculturally and the economic situation of this region has witnessed partial improvement. The main cultivation of the region includes wheat, barley, vegetables and fodder.

2. MATERIALS AND METHODS

Quds irrigation and drainage network

Quds irrigation and drainage network was commissioned in the lands of lower Karkheh area in Khuzestan province. The lands are on the right side of Karkheh River and 32 km away to the west of Ahwaz city and 7 km away to the west of Hamidieh city. These lands are located between the north latitude of 31^0 29' - 31^0 35' and between east longitude of 48^0 16' - 48^0 23'. Gross and net areas of these lands are 3200 and 2719 hectares, respectively. Quds region is surrounded by Allah Akbar hills in the north and northeast and by the Karkheh River in the East The area experiences long hot summers with low humidity and mild and short winters. Minimum and maximum temperatures occur in July and January, respectively. Annual rainfall is low and its distribution is more from February to December. General plan of Quds irrigation network is shown in the map of Fig. 1.

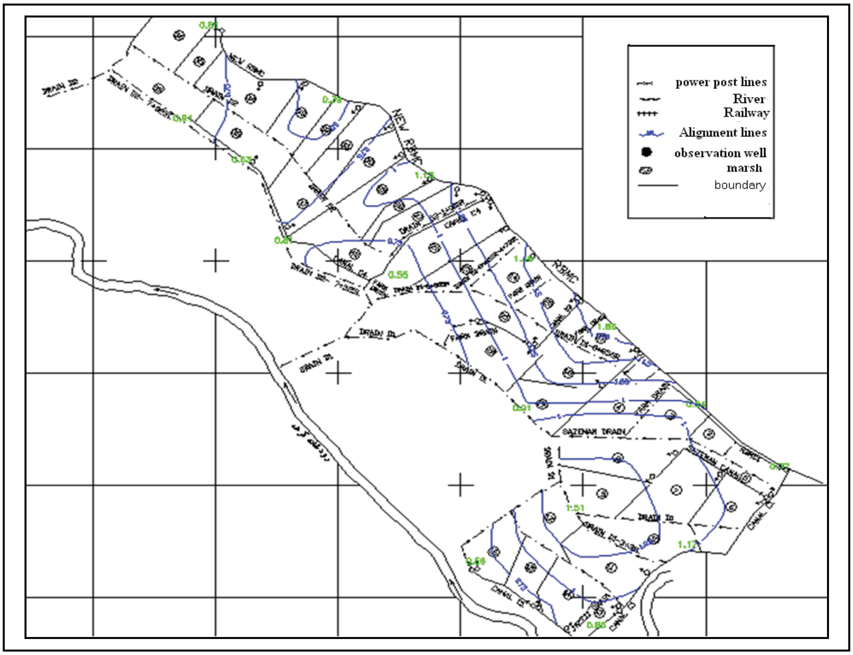

Fig. 1. Plan of Quds irrigation network

Water resources

The source of water for the Quds regional lands and in general for the Azadegan plain is the Karkheh River. This river supplies required water for the regional lands downstream to the dam through the main channel at the right side of the river.

Main Channel in the right side of Kharkheh sub-dam (Quds channels)

Quds channel was built in 1951-1954 and supplies the required water for irrigation and drainage project of Quds district. This channel from its beginning to 13 +805 km serves as a water supply channel and then enters into the lands of Quds project. The design flow capacity of the channel was 10 cumecs and after changing the basic features of the channel, it now transfers water at a maximum of 5 cumecs.

Soil Resources

Soil in this area is formed from alluvial deposits that are carried by Karkheh River. Range sediments in northern border of the region and the sandy soil set of northeastern has been effective in formation of the region's soil. The general slope is mild from south east to northwest. In the east region there is a mild bulge that its steep goes to the west. Generally central area slope is about 0.2 – 0.1 per cent and in the north border it is about 0.5 per cent. The Central strip of the region along southeast - northwest has a soil with i.CL that is greater in depth area and has changed in to Si.C – C texture. Only small parts of the soil along the Kharkheh River and along the north hills have light texture (SL-Si.LL). The soils of the region are generally saline with about 50% of the land under ‘High salinity’ category and 25% under ‘Very high’ salinity category. The rest 25% of the land has moderate or low sanlinity.

Irrigation and drainage networks

The irrigation and drainage network operation including grade 1 and 2 channels and drainages in the Quds region started in 1986 and now it is under renovation. Required water for irrigation of Quds channel is supplied through the main channel in the right side of Kharkheh Dam (Quds Channel). This network uses some grade 1 and 2 channels to supply required water of agricultural units that its area is between 60-100 acres .Drainage of agricultural units is done using a constant head orifice that leads water into drain pipes of diameter 60 to 80 cm. Surface drainage network of Quds region includes several open drainage channels that collect the runoff and excess irrigation water, which is pumped back to the Kharkheh River through pumping stations No. 1 and 2.

Quds surface drainage network no.1and 2

Surface drainage network of Quds has been built longs ago before implementation of the new irrigation and drainage projects of Quds and Hamidieh. This network has been adversely affected due to floods in Karkheh River’s in the past and also due to growth of weeds and continuous sedimentation. Surface drainage network of Quds has three main drainage carriers called D1, D2 and D3. Total area covered by this network is about 3200 hectares. This network, in addition to collecting and emptying runoffs of the lands covered by the plan also collects and transfers runoffs from the hills at the north and northeast through six culverts.

Soil hydraulic conductivity coefficient (K)

In drainage investigations it is necessary that hydraulic conductivity of soil to be measured about a meter bellow the depth of installed drainage. If an impenetrable layer is encountered then the depth of hydraulic conductivity measurement will be limited to depth of impervious layer and otherwise according to the depth of installation of underground drainage sump (3 m from the ground). Table 1 illustrates classification of Quds region lands in terms of hydraulic conductivity (K) coefficient.

Table 1. Classification of Quds region lands according to K

%	Area (ha)	descriptive	(m/day)K
–	–	Slowly	< 0.5
28.53	913	medium	0.5 – 1
34.38	1100	Rather Fast	1 – 1.5
29.06	930	Fast	1.5 – 3
8.03	257	Too Fast	> 3
100	3200		

Infiltration rate of soil

Rate of water infiltration at the soil surface is expressed in cm/h. If the infiltration rate is low then it leads to surface water congestion and causes the major problem of inadequate surface drainage of the land. Classification of soil according to infiltration is based on the final infiltration rate (BIR) at any point (Table 2).

Table 2 . Soil classification by infiltration rate.

Description	Infiltration Rate (cm/h)
Very slow	< 0.1
Slow	0.1 – 0.4
Medium	0.4 – 0.8
Fast	0.8 – 2
Too Fast	> 2

Among total of 22 measured points, infiltration rate at three-points was very slow; at seven points slow; at four points moderate; at four points fast and at 4 points it was very fast.

Limiting and impermeable layers of soil

Limiting layers are those with little permeability and enough thickness to prevent leakage of water beneath the layer. In Quds area the limiting and impermeable layers, which are important in underground drainage issues, are at depths of 5.5 to 6 meters in different areas.

Results of groundwater studies in 1991 - 92

Study of groundwater in irrigation and drainage projects is essential to solve drainage problems. These studies are to assess the fluctuation of static water level, flow gradient and flow direction and groundwater quality.

• Review of static level fluctuations

In this study the static levels in observation wells was measured in 12 months and maps of groundwater contours were drawn and the area of lands with the same level of groundwater determined. According to the results, the March water table in the Quds region was shallower than 1 m in 3015 ha out of the total of 3200 ha.. Generally in March the level of ground water in the whole land was shallower than 0.5 m from the ground surface. Also in October of the same year the static level reached to its deepest level during the course of the present study.

• Flow direction and gradient of groundwater

The groundwater movement and gradient of the study region somewhat follows land topography and land slope, i.e., from north to south. Ground water movements from the north constitutes the major component og groundwater flow. Old channel of RBMC which has too much leakage and also lands under irrigation of north area in this plan are among other sources of underground water supplies. Also maximum amount of hydraulic gradient in the region equals 0.2 per cent.

• Chemical quality of groundwater

Study of the chemical parameters of groundwater is one of the important components of drainage investigations. Dangers of soil salinity and alkalinity and also determination of critical areas which are in priority for deep drainage intervention could be ascertained by using the results of water quality study.

Maximum and minimum levels of salinity in the groundwater in the Quds area during 1991 -92 was 291 and 3.6 mm/cm. Salinity level changes of groundwater were according to fluctuations of the groundwater levels. Results of Iso-Conductivity maps for October and March associated with salinity of the groundwater has been presented in Table 3.

Table 3. Changes in the levels with the same EC at maximum level (October) and the minimum level (March)

Month		EC m-moh/cm
1984 March	1984 October	
492	267	< 10
844	637	10 – 20
392	455	20 – 30
200	416	30 – 40
176	564	40 – 50
1096	861	> 50
3200	3200	

• Chloride in groundwater

Analysis of groundwater samples revealed a high concentration of Cl^- ions in them, which is toxic for the plants. The maximum chlorine concentration in the groundwater was 16,659 meq/l. Changes in the amount of chlorine is associated with fluctuations in the groundwater levels. Also there is some amount of bicarbonate in the region between 1.2 to 9.6 meq/l and acidity changes (PH) of underground waters about 6.6 – 8.2.

• Static water level

Figure 2 shows the locations of the observation wells in the study area. Water table observations were taken in the observation wells and the results from October 2002 through September 2003 are given in Table 4.

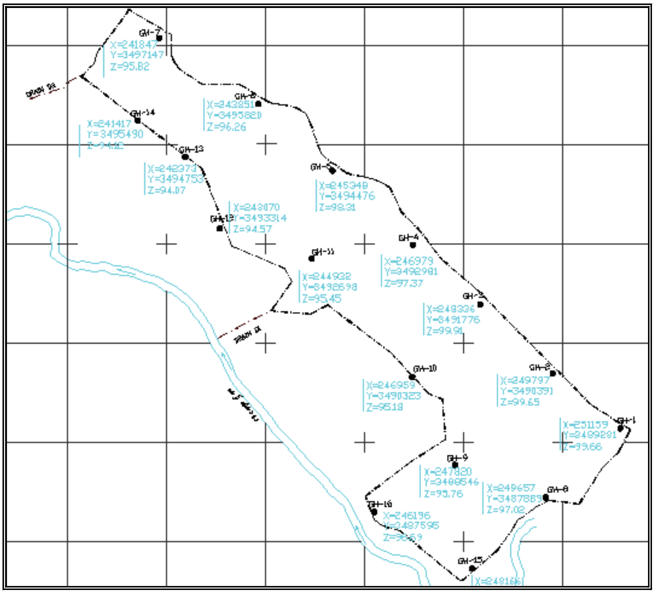

Fig. 2. Location of observation wells in the study region

Table 4. Summary of static water table depth measured from ground level.

ID	ore Hole Dept	Ground Surface	October	Novembe	December	January	Febrary	March	April	May	June	July	August	eptembe
GH1	6.0	99.66	1.37	1.34	1.41	1.07	1.28	0.95	0.77	1.12	1.38	1.31	1.57	1.59
GH2	5.0	99.65	0.54	0.99	1.28	0.90	1.15	0.46	0.94	0.90	0.93	1.04	1.17	1.35
GH3	5.5	99.91	2.23	2.14	2.15	2.04	2.00	1.95	1.86	1.84	1.81	1.76	1.91	1.94
GH4	6.0	97.37	2.15	2.02	1.91	1.74	1.64	1.55	1.49	1.46	1.52	1.63	1.83	1.96
GH5	6.0	98.31	1.48	1.43	1.32	0.98	1.12	0.77	1.13	1.40	1.47	1.10	1.08	1.08
GH6	5.5	96.26	0.51	0.52	0.56	0.51	0.39	0.20	0.39	0.53	0.67	0.00	0.00	0.00
GH7	5.3	95.82	0.99	0.78	0.73	0.92	0.76	0.71	0.81	0.84	1.04	1.07	1.05	1.44
GH8	6.0	97.02	2.08	2.34	1.91	1.23	1.55	1.25	1.17	1.06	0.97	1.42	0.96	1.81
GH9	6.0	95.76	0.91	1.30	1.36	1.05	1.30	1.36	1.51	1.51	1.76	1.64	0.96	1.54
GH10	5.0	95.18	1.81	1.81	1.66	1.10	1.17	0.74	le Dpt	0.90	1.62	1.46	0.91	1.01
GH11	5.5	95.45	0.80	0.85	0.73	0.65	0.48	0.28	0.55	0.58	0.78	0.35	0.73	0.68
GH12	5.5	94.57	1.05	0.79	0.87	0.83	0.89	0.74	0.81	1.04	0.95	0.57	0.54	0.54
GH13	6.0	94.07	1.14	1.02	0.79	0.70	0.73	0.62	0.63	0.82	0.68	0.63	0.00	0.24
GH14	6.0	94.12	1.35	1.09	0.83	1.09	1.00	0.95	0.91	1.25	1.24	0.49	0.54	0.54
GH15	6.0	97.33	0.45	0.87	1.01	0.94	1.22	0.84	0.85	1.22	1.74	1.75	1.54	1.85
GH16	6.0	96.69	3.40	2.71	2.19	1.26	0.93	0.85	0.56	0.49	0.26	0.24	1.00	0.96

3. RESULTS AND DISCUSSION

Reason for draining the lands

Various factors leading to drainage need of an area are:

- Topography and natural position of lands
- Regional soil conditions
- Rainfall

- Runoff inflow from surrounding areas
- Deep infiltration of irrigation water and leakage of traditional rivers

Each of these factors are briefly described below:

• Topography and natural position of lands

Topography of the Quds area shows slopes generally milder than 0.5%. In many parts the land slope is much flatter. Mild slope impedes surface runoff, which increases infiltration. Northern areas of the project have relatively steep slope, which becomes milder towards the middle. Efficiency of surface drainage network also depends on topographic features and land slope. Unfortunately however, these features in the Quds area do not support good drainage and hence, the surface drainage network has little impact.

• regional soil conditions

Soil texture in Quads lands, except in a limited area, is of a heavy and very heavy type and has little infiltration. In many parts, there are heavy surface layers with low infiltration which lead to salinity and alkalinity of soils and are important contributors of drainage problems in the area.

• Rainfall

Annual rainfall in the region is low but the rainfall, especially in the rainy months, after passing through layers of soil is added to the groundwater. Usually 20 to 30 percent of the total rainfall of the region joins the groundwater aquifers and this causes drainage problems.

• Inflow of runoff from the surrounding areas

In the Quds area there are some factors that aggravate the naturally occurring land drainage problems. These are:

- Surface runoff and underground streams of hills and adjoining high lands.
- Water leakage from the RBMC channel.
- Loss of applied irrigation water inherent to the traditional irrigation methods that may reach and even exceed 50 percent.
- Loss of water to the tune of average 15 per cent due to leakage while transferring water from the channel of certain hierarchical order to another.

Groundwater maps

Groundwater conditions can be studied in the best way with drawing a regional groundwater table depth map. Following maps are most useful in this regard:

- Static depth level map
- Static balance level map

- Fluctuation map of underground level (static level and potential metric level)
- A map which shows the differences between the static level and potential metric level
- Ground water quality map

We shall briefly review the first three maps used in this study:

• Static level depth map

In this map regions with the same depth of groundwater table are identified at a suitable interval. This map is used for identification and separation of potential drainage areas.

In prioritizing areas for drainage intervention, the most important factors are the depth to static water table and quality of groundwater. There are different classifications in terms of the severity level of drainage needs based on depth of static level in different literatures but there is no significant difference among them. Table 5 shows relative rating of drainage needs based on depth of static level.

Table 5. Classifying drainage need in relation to the depth of the static water level.

Need for Drainage	Water Table Depth			Row
	Sign on the Map	Description	Relative to Ground Surface (m)	
Very extreme	V.S	Too Shallow	0-1	1
extreme	S	Shallow	1-1.5	2
Medium	M	medium	1.5 - 2	3
Poor	M.D	Partly Deep	2 – 2.5	4
Not Needed	D	Deep	> 2.5	5

In order to have easier comprehension of the results, land parcels with the same depth or more commonly, same depth ranges of the water table are coded with uniform colour in the map. Below the map there is a Pie chart of area and percentage of land area of the network according to different water table depth ranges in the indicated month. Also descriptive name of related degree is listed on the sign map (Mark) about the depth of groundwater. So every month two static water table maps were prepared – one for depth to water table and the other for percentage of area under different water table dpth ranges.

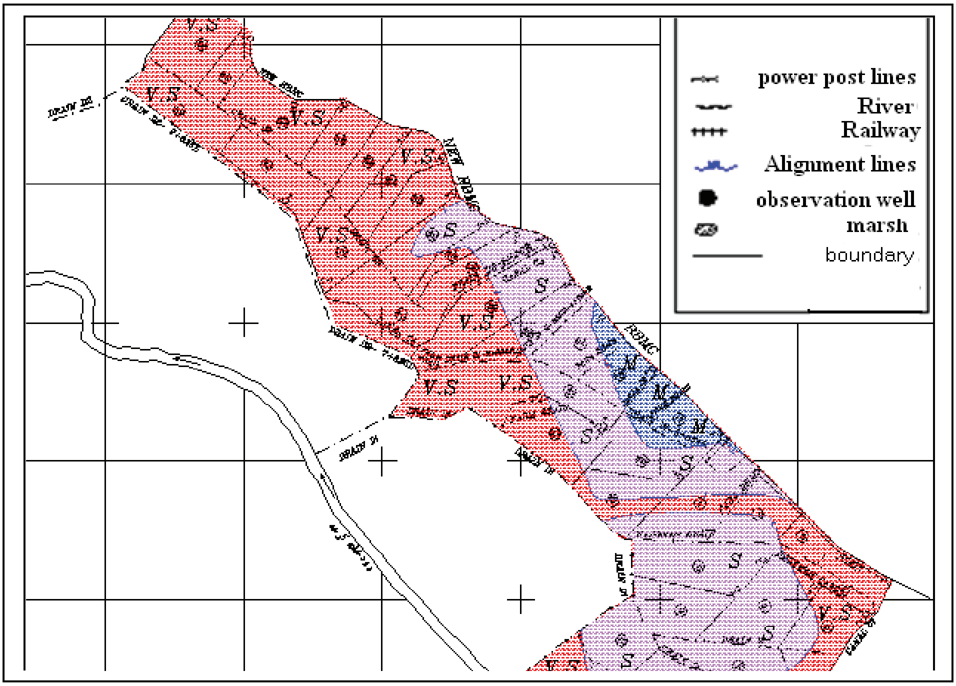

Fig. 3. Iso-bath Map of the study area

The results of cumulative area and percentage of cumulative area to total area corresponding to the different water table depth ranges is given in Fig. 4.

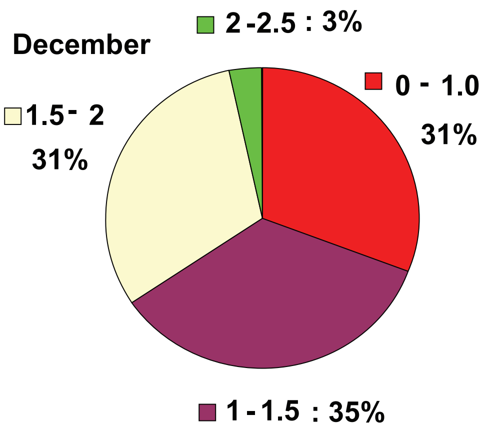

Fig. 4. Areas under different water table depth ranges

4. CONCLUSIONS

Relative rating of deep drainage needs is offered based on highest static level (shallowest depths to water table) but in fact according to figures 3 and 4 and the results of hydrograph derived from observation wells data, network status in terms of depth to static level is so shallow (critical) that there is no need to introduce the most critical months. Generally it can be observed that according to hydrograph computing of the unit, the deepest static level depth occured in October, 2002 (water table depth 1.37 m below the ground) and the shallowest static level occurred in March 2003 (0.9 m below ground level). For all the other months, water table depths were within this range.

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