POLISH JOURNAL OF NATURAL SCIENCES
Abbrev.: Pol. J. Natur. Sc., Vol 29(1): 55–75, Y. 2014

COMPARISON OF LAND SUITABILITY FOR DIFFERENT IRRIGATION METHODES IN SHOIBIEH PLAIN (SW IRAN)

***Mohammad Albaji*[1], *Mona Golabi*[1], *Abd Ali Naseri*[1], *Aslan Egdernejad*[2], *Farzad Nazari Zadeh*[3]**

[1] Irrigation and Drainage Department
Shahid Chamran University in Ahvaz, Iran
[2] Irrigation Department
Khouzestan Science and Research Branch, Islamic Azad University in Ahvaz, Iran
[3] Khouzestan Water and Power Authority (KWPA) in Ahvaz, Iran

Key words: drip irrigation, soil series, sprinkler irrigation, surface irrigation, land suitability evaluation.

Abstract

The main objective of this research is to evaluate and compare land suitability for different irrigation methods based upon a parametric evaluation system in an area of 49 622 ha in the Shoibieh Plain, SW Iran. The obtained results showed that for 18 804.64 ha (37.9%) of the study area surface irrigation method was highly recommended; whereas for 36 046.49 ha (72.6%) of the study area a sprinkler irrigation method would provide to be extremely efficient and suitable. The results demonstrated that by applying sprinkler irrigation instead of surface and drip irrigation methods, the arability of 48 805.43 ha (98.3%) in the Shoibieh Plain will improve. The comparison of the different types of irrigation revealed that sprinkler irrigation was more effective and efficient then the drip and surface irrigation methods for improving land productivity. It is of note however that the main limiting factor in using sprinkler irrigation methods in this area was calcium carbonate content.

PORÓWNANIE PRZYDATNOŚCI RÓŻNYCH METOD NAWADNIANIA GRUNTÓW W SHOIBIEH PLAIN (PŁD.-ZACH. IRAN)

***Mohammad Albaji*[1], *Mona Golabi*[1], *Abd Ali Naseri*[1], *Aslan Egdernejad*[2], *Farzad Nazari Zadeh*[3]**

[1] Katedra Nawadniania i Drenażu
Uniwersytet Shahida Chamrana w Ahvazie, Iran
[2] Katedra Nawadniania, Oddział Nauki i Badań Khouzestanu
Islamski Uniwersytet Azada w Ahvazie, Iran
[3] Zarząd Wody i Energii Khouzestanu (KWPA) w Ahvazie, Iran

Słowa kluczowe: nawadnianie kropelkowe, deszczowanie gleb, nawadnianie powierzchniowe, ocena przydatności gruntów.

Address: Mohammad Albaji, Shahid Chamran University, Ahwaz, Iran, 61357-43311, phone: +98 611 313 55 89, e-mail: m_albaji2000@yahoo.co.uk

Abstrakt

Głównym celem badań była ocena i porównanie przydatności różnych metod nawadniania gruntów w oparciu o system oceny parametrycznej na obszarze 49 622 ha w Shoibieh Plain w Iranie. Dowiedziono, że dla 18 804,64 ha (37,9%) badanego obszaru najbardziej zalecana jest metoda nawadniania powierzchniowego, natomiast dla 36 046,49 ha (72,6%) powierzchni korzystna i niezwykle wydajna jest metoda deszczowania. Rezultaty badań wskazują, że po zastosowaniu deszczowania, zamiast metod nawadniania powierzchniowego i kropelkowego, wzrośnie żyzność gleb na powierzchni 48 805,43 ha (98,3%) w Shoibieh Plain. Z porównania różnych rodzajów nawadniania wynika, że deszczowanie skuteczniej i efektywniej wpłynęło na poprawę produktywności gruntów niż kropelkowe i powierzchniowe metody nawadniania. Należy jednak zauważyć, że głównym czynnikiem ograniczającym wykorzystanie metody deszczowania na tym obszarze była zawartość węglanu wapnia.

Introduction

In Shoibieh Plain located in the Khuzestan Province, in the South West of Iran irrigation practices can be very expensive and may cause negative phenomena, such as salinisation, alkalization, drainage limitation, soil erosion and finally land degradation. Main causes of these limitations are: lack of appropriate irrigation water management, leaching, and lack of appropriate drainage facilities.

On the other hand, due to the depletion of water resources and an increase in population, the extent of irrigated area per capita is declining and irrigated lands now produce 40% of the food supply (HARGREAVES and MEKLEY 1998). According to FAO methodology (1976) land suitability is strongly related to „land qualities" including erosion resistance, water availability and flood hazards which are derived from slope and length, rainfall and soil texture. SYS et al. (1991) suggested a parametric evaluation system for irrigation methods which was primarily based on physical and chemical soil properties.

DENGIZ (2006) also compared different irrigation methods including surface and drip irrigation in the pilot fields of Central Research Institute, Lkizce research farm located in Southern Ankara. He concluded that the drip irrigation method increased the land suitability by 38% compared to the surface irrigation method.

GIZACHEW and NDAO (2008) evaluated the land suitability for surface (gravity) and drip (localized) irrigation in the Enderta District, Tigray, Ethiopia, using Sys's parametric evaluation systems. Drip irrigation can be a good method of irrigation in this region, if it is managed properly (best design, filters, etc.)

BROU and WOLDEGIORGIS (2009) performed a land suitability evaluation for two types of irrigation i.e., surface irrigation and drip irrigation, in the Kilte Awulaelo District – Tigrayregion – Ethiopia using the suggested parametric evaluation. As the study area is composed of heterogeneous physiographic features, dominantly from undulating to steep scarp, the drip irrigation suitability gave more irrigable areas compared to the surface irrigation practice, due to the topographic (slope), soil (depth and texture), surface stoniness and drainage limitations worked out in the surface irrigation suitability evaluation.

ALBAJI et al. (2009a) compared the suitability of land for surface and drip irrigation methods according to a parametric evaluation system in the plains west of the city of Shush, in the southwest Iran. The results indicated that a larger amount of the land (30,100 ha – 71.8%) can be classified as more suitable for drip irrigation than surface irrigation.

Using irrigation, farmers have to apply a lot of water to the crops and soil. In order to avoid land degradation, irrigation water and techniques must be compatible with the soil properties. For this reason, it is necessary to evaluate the suitability of land for irrigation. Therefore, the main objective of this research is to evaluate and compare land suitability for surface, sprinkler and drip irrigation methods based on the parametric evaluation systems for the Shoibieh Plain, in the Khuzestan Province, South West of Iran.

Materials and Methods

Study Area

The present study was conducted in an area about 49 622 hectares in the Shoibieh Plain, in the Khuzestan Province, located in the South West of Iran during 2010–2011 (Figure 1). The study area is located 40 km North of the city

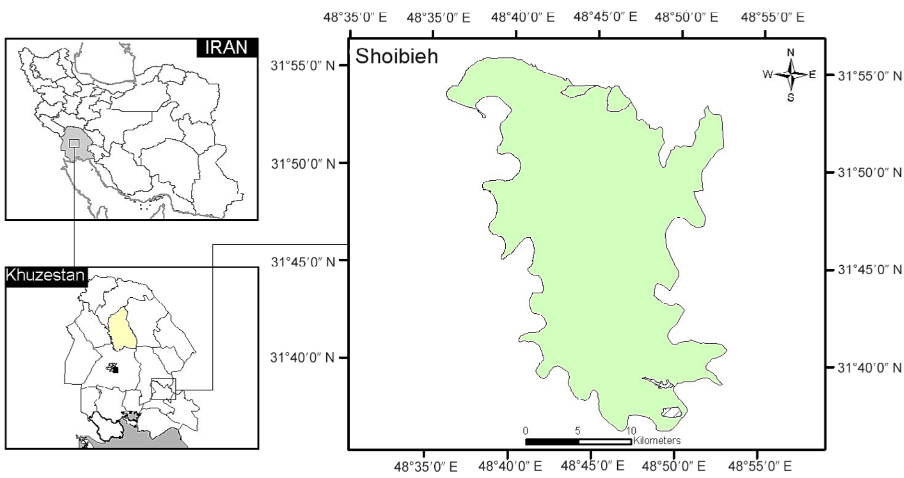

Fig. 1. Local map of the study area

of Ahwaz, 31° 36’ to 31° 54’ N and 48° 37’ to 48° 53’ E. The average annual temperature and precipitation for the period of 1959–2009 were 25.30 C° and 335.70 mm, respectively. Also, the annual Potential Evapotranspiration (PET) of the area is 1755.82 mm (Table 1) (TORFI 2010). But, due to the irrigation water quality parameters (such as EC<1 dS m^{-1} and etc) are in good condition, the problem of high PET not influences high salinity of water, and limits the use of pressurized irrigation systems.

Table 1

Mean air temperature, relative humidity and total monthly rainfall and evaporation (1959–2009) at Shushtar

Parameter	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Temperature [°C]	12.80	14.50	18.50	24.20	30.20	34.50	37.20	37.00	33.90	27.90	20.80	15.00	25.30
Relative humidity [%]	72.00	66.20	53.40	42.10	28.30	22.20	23.30	25.10	25.90	34.90	52.70	68.70	42.90
Total Rainfall [mm]	69.30	44.00	61.50	28.30	8.70	0	0	0	0	6.50	27.10	90.30	335.70
Potential ET [mm]	28.20	33.80	62.83	110.56	208.73	272.08	272.52	267.81	223.03	143.9	86.42	45.94	1755.82

Irrigation Schemes

The Karun River supplies the bulk of the water demands of the region. The application of irrigated agriculture has been common in the study area. Over much of the Shoibieh Plain, the use of surface irrigation systems has been applied for crops. The major irrigated crops grown in this area are wheat, barley, alfalfa and maize. There are very few instances of sprinkler and drip irrigation on large area farms in the Shoibieh Plain. Currently, the irrigation systems used by farmlands in the region are furrow irrigation, basin irrigation and border irrigation schemes.

Soil Sampling and Analyses

The area is composed of three distinct physiographic features i.e. River Alluvial Plains and Plateaux and Terraces, of which the River Alluvial Plains physiographic unit is the dominating feature. Also, twelve different soil series were found in the area (Table 2). The semi-detailed soil survey report of the Shoibieh Plain (ALBAJI 2008) was used in order to determine the soil characteristics. Table 3 has shown some of physico-chemical characteristics for reference profiles of different soil series in the plain. The land evaluation was determined based upon topography and soil characteristics of the region (ALBAJI et al. 2009b). The topographic characteristics included slope and soil properties such as soil texture, depth, salinity, drainage and calcium carbonate content were taken into account (BEHZAD et al. 2009). Soil properties such as cation exchange capacity (CEC), percentage of basic saturation (PBC), organic mater (OM) and pH were considered in terms of soil fertility (SYS et al. 1991). SYS et al. (1991) suggested that soil characteristics such as OM and PBS do not require any evaluation in arid regions whereas clay CEC rate usually exceeds the plant requirement without further limitation, thus, fertility properties can be excluded from land evaluation if it is done for the purpose of irrigation. According to the particular semi-detailed studies of the region, samples were taken from each soil series profiles and laboratory analysis were carried out based upon the conventional methods of the Iranian Soil and Water Research

Table 2

Soil series of the study area

Series No.	Characteristics description
1	soil texture „medium: L", slight salinity and alkalinity limitation, depth 130 cm, gently sloping: 2 to 5% well drained
2	soil texture „medium: SL", without salinity and alkalinity limitation, depth 150 cm, level to very gently sloping: 0 to 2%, well drained
3	soil texture „medium: SL", without salinity and alkalinity limitation, depth 60 cm, gently sloping: 2 to 5%, well drained
4	soil texture „medium: SL", without salinity and alkalinity limitation, depth 160 cm, gently sloping: 2 to 5%, well drained
5	soil texture „medium: SIL", slight salinity and alkalinity limitation, depth 135 cm, level to very gently sloping: 0 to 2%, well drained
6	soil texture „heavy: SICL", without salinity and alkalinity limitation, depth 140 cm, level to very gently sloping: 0 to 2%, well drained
7	soil texture „heavy: SICL", very without salinity and alkalinity limitation, depth 150 cm, level to very gently sloping: 0 to 2% well drained
8	soil texture „heavy: SCL", without salinity and alkalinity limitation, depth 150 cm, level to very gently sloping: 0 to 2% well drained
9	soil texture „heavy: SICL", slight salinity and alkalinity limitation, depth 130 cm, level to very gently sloping: 0 to 2% well drained
10	soil texture „heavy: SICL", severe salinity and alkalinity limitation, depth 140 cm, level to very gently sloping: 0 to 2% moderately drained
11	soil texture „medium: SIL", without salinity and alkalinity limitation, depth 150 cm, level very gently sloping: 0 to 2% moderately drained
12	soil texture „very heavy: SIC", without salinity and alkalinity limitation, depth 140 cm, level to very gently sloping: 0 to 2%, imperfectly drained

Texture symbols: SL – sandy loam; L – loam; SCL – sandy clay loam; SICL – silty clay loam; SIL – silty loam; SIC – silty clay.

Table 3

Some of physico-chemical characteristics for reference profiles of different soil series

Soil series No.	Soil series name	Depth [cm]	Soil texture	ECe [ds m^{-1}]	pH	OM [%]	CEC [meq/100 g]	$CaCO_3$ [%]
1	Qhaleh Khan	130	L	4.10	7.60	0.62	12.36	43.00
2	Sheykh Hossein	150	SL	1.50	7.50	0.14	11.92	42.00
3	Bala	60	SL	3.20	7.90	0.24	10.54	44.00
4	Kakoli	160	SL	0.50	8.20	0.08	11.47	51.00
5	Abbasieh	135	SIL	5.90	7.60	0.39	12.73	44.00
6	Karun	140	SICL	1.00	7.60	0.41	10.22	51.00
7	Deylam	150	SICL	2.90	7.50	0.32	10.81	49.00
8	Qalimeh	150	SCL	1.50	7.90	0.26	12.05	49.00
9	Abdul Amir	130	SICL	7.50	7.80	0.57	10.38	46.00
10	Khoshmakan	140	SICL	31.00	7.60	0.20	10.87	44.00
11	Karkheh	150	SIL	1.90	7.70	0.37	9.26	50.00
12	Dez	140	SIC	3.50	7.60	0.39	10.64	40.00

Institute (JALALI 1997, MAHJOOBI et al. 2010), and the following properties were measured by due methods: electrical conductivity by conductivity meter (inoLab, Con Level 1, WTW), soil texture by agitator and hydrometer and lime settlement rate by titration method (PAGE et al. 1992).

The groups of soils that had similar properties and were located in a same physiographic unit were categorized as soil series and were classified to form a soil family as per the *Soil Survey Staff* (2008). Ultimately, twelve soil series were selected for the surface, sprinkler and drip irrigation land suitability. Twelve soil series and forty nine series phases were derived from the semi-detailed soil study of the area. The soil series are shown in Figure 2 as the basis for further land evaluation practice. The soils of the area are of Aridisols and Entisols orders *(Soil Survey Staff*. 2008). Also, the soil moisture regime is Aridic while the soil temperature regime is Hyperthermic (ALBAJI 2008).

In order to obtain the average soil texture, salinity and $CaCO_3$ for the upper 150 cm of soil profile, the profile was subdivided into 6 equal sections and weighting factors of 2, 1.5, 1, 0.75, 0.50 and 0.25 were used for each section, respectively (Sys et al., 1991). Due to topsoil (0–75 cm) is important than subsoil (75–150 cm) for plant growth (plant nutrition, water absorption and etc), thus the weighting factors of topsoil (2, 1.5, 1) are bigger than subsoil (0.75, 0.50, 0.25).

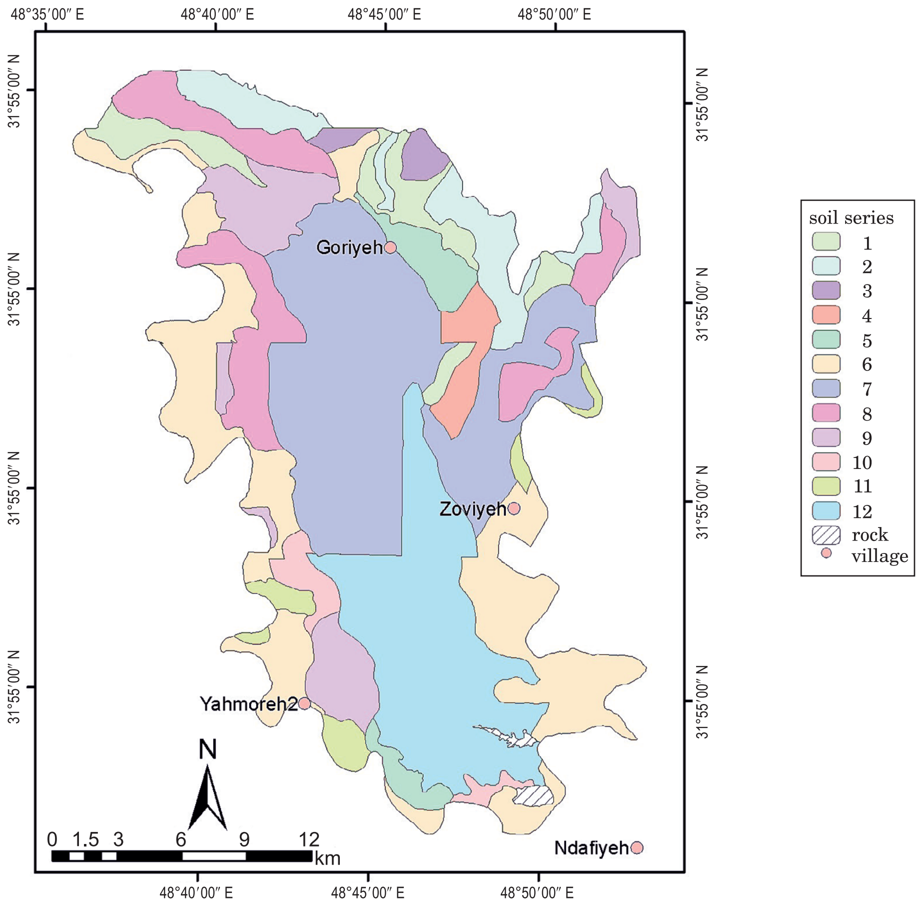

Fig. 2. Soil map of the study area

For the evaluation of land suitability for surface, sprinkler and drip irrigation, the parametric evaluation system was used (SYS et al. 1991). This method is based on morphology, physical and chemical properties of soil. The method, the land is evaluated according to numerical indexes. In this classification system, firstly a degree, whose rate is from 0 to 100, is given to any land characteristic through comparing them with the tables of soil requirements. The specified degrees are used in order to measure the land index that is a multiplicative index that combines ratings assigned to soil map units and other physical conditions that affect the land use (OLSEN 1981).

The chemical and physical soil proprieties are determined in the soil laboratory of Khuzestan Water and Power Authority using different kinds of analyses processing (ALBAJI 2008). This approach allows a calculation

Table 4

Rating of textural classes for irrigation

Tex	Rating for surface irrigation					Rating for sprinkler irrigation					Rating for drip irrigation				
	fine gravel [%]			coarse gravel [%]		fine gravel [%]			coarse gravel [%]		fine gravel [%]			coarse gravel [%]	
	< 15	15–40	40–75	15–40	40–75	< 15	15–40	40–75	15–40	40–75	< 15	15–40	40–75	15–40	40–75
CL	100	90	80	80	50	100	90	80	80	50	100	90	80	80	50
SiL	100	90	80	80	50	100	90	80	80	50	100	90	80	80	50
SCL	95	85	75	75	45	95	85	75	75	45	95	85	75	75	45
L	90	80	70	70	45	90	80	70	70	45	90	80	70	70	45
SiL	90	80	70	70	45	90	80	70	70	45	90	80	70	70	45
Si	90	80	70	70	45	90	80	70	70	45	90	80	70	70	45
SiC	85	95	80	80	40	85	95	80	80	40	85	95	80	80	40
C	85	95	80	80	40	85	95	80	80	40	85	95	80	80	40
SC	80	90	75	75	35	95	90	80	75	35	95	90	85	80	35
SL	75	65	60	60	35	90	75	70	70	35	95	85	80	75	35
LS	55	50	45	45	25	70	65	50	55	30	85	75	55	60	35
S	30	25	25	25	25	50	45	40	30	30	70	65	50	35	35

Tex – textural classes: CL – clay loam; SiL – silty loam; SCL – sandy clay loam; L – loam; SiL – silty loam; Si – silty; SiC – silty clay; C – clay; SC – sandy clay; SL – sandy loam; LS – loamy sand; S – sandy of a suitability index for irrigation considering some factors influencing the soil suitability. These factors are (SYS et al. 1991):

– soil texture: rated taking in account the permeability and available water content, and calculated, as weighted average, for the upper 100 cm;

– soil depth: rated with regard to the thickness and the characteristic of the soil layers (horizons);

– calcium carbonate content: influencing the relationship between soil and water, and the availability of nutrient supply for plant (150 cm of soil profile). It is rated with regard to the $CaCO_3$ content effect on soil profile;

– salinity: rated on the base of the electrical conductivity of soil solution;

– drainage: a limiting factor when it is imperfect or weak. The rating for drainage is related to texture;

– slope: estimated considering the difference between terraced and non-terraced slopes.

These factors (including soil texture, soil depth, calcium carbonates status, electrical conductivity of soil solution, drainage properties and slope) were also considered and values were assigned to each factors as per the related tables (Tables 4–9) [SYS et al. (1991) for surface and drip irrigation; ALBAJI (2010a) for sprinkler irrigation].

Thus, the capability index for irrigation (*Ci*) was developed as shown in the equation below:

$$Ci = A \cdot \frac{B}{100} \cdot \frac{C}{100} \cdot \frac{D}{100} \cdot \frac{E}{100} \cdot \frac{F}{100}$$

where:
A – rating of soil texture;
B – rating of soil depth;
C – rating of calcium carbonate content;
D – rating of electrical conductivity;
E – rating of soil drainage;
F – rating of soil slope.

Table 5

Rating of soil depth for irrigation

Soil depth [cm]	Rating for surface irrigation	Rating for sprinkler irrigation	Rating for drip irrigation
< 20	25	30	35
20–50	60	65	70
50–80	80	85	90
80–100	90	95	100
> 100	100	100	100

Table 6

Rating of $CaCO_3$ for irrigation

$CaCO_3$ [%]	Rating for surface irrigation	Rating for sprinkler irrigation	Rating for drip irrigation
<0.3	90	90	90
0.3–10	95	95	95
10–25	100	100	95
25–50	90	90	80
>50	80	80	70

Table 7

Rating of salinity for irrigation

EC [ds m^{-1}]	Rating for surface irrigation		Rating for sprinkler irrigation		Rating for drip irrigation	
	C, SiC, SiCL, S, SC textures	other textures	C, SiC, SiCL, S, SC textures	other textures	C, SiC, SiCL, S, SC textures	other textures
< 4	100	100	100	100	100	100
4–8	90	95	95	95	95	95
8–16	80	50	85	50	85	50
16–30	70	30	75	35	75	35
> 30	60	20	65	20	65	25

C – clay; SiC – silty clay; SiCL – silty clay loam; S – sand; SC – sandy clay

Table 8

Rating of drainage classes for irrigation

Drainage classes	Rating for surface irrigation		Rating for sprinkler irrigation		Rating for drip irrigation	
	C, SiC, SiCL, S, SC textures	other textures	C, SiC, SiCL, S, SC textures	other textures	C, SiC, SiCL, S, SC textures	other textures
Well drained	100	100	100	100	100	100
Moderately drained	80	90	90	95	100	100
Imperfectly drained	70	80	75	85	80	90
Poorly drained	60	65	65	70	70	80
Very poorly drained	40	65	45	65	50	65
Drainage status not known	70	80	70	80	70	80

C – clay; SiC – silty clay; SiCL – silty clay loam; S – sand; SC – sandy clay

Table 9

Rating of slope for irrigation

Slope classes [%]	Rating for surface irrigation		Rating for sprinkler irrigation		Rating for drip irrigation	
	non-terraced	terraced	non-terraced	terraced	non-terraced	terraced
0–1	100	100	100	100	100	100
1–3	95	95	100	100	100	100
3–5	90	95	95	100	100	100
5–8	80	90	85	95	90	100
8–16	70	80	75	85	80	90
16–30	50	65	55	70	60	75
> 30	30	45	35	50	40	55

In Table 10 the ranges of capability index and the corresponding suitability classes are shown.

Table 10

Suitability classes for the irrigation capability indices (*Ci*) classes

Capability index	Definition	Symbol
> 80	highly suitable	S_1
60–80	moderately suitable	S_2
45–59	marginally suitable	S_3
30–44	currently not suitable	N_1
< 29	permanently not suitable	N_2

Land Suitability Maps

In order to develop land suitability maps for different irrigation methods, a semi-detailed soil map (Figure 2) prepared by Albaji was used, and all the data for soil characteristics were analyzed and incorporated in the map using ArcGIS 9.2 software.

The digital soil map base preparation was the first step towards the presentation of a GIS module for land suitability maps for different irrigation systems. The soil map was then digitized and a database prepared. A total of twelve different polygons or soil series were determined in the base map. Soil characteristics were also given for each soil series. These values were used to generate the land suitability maps for surface, sprinkler and drip irrigation systems using Geographic Information Systems. In Figure 3 schematic chart of GIS application for land suitability map for different Irrigation methods is shown.

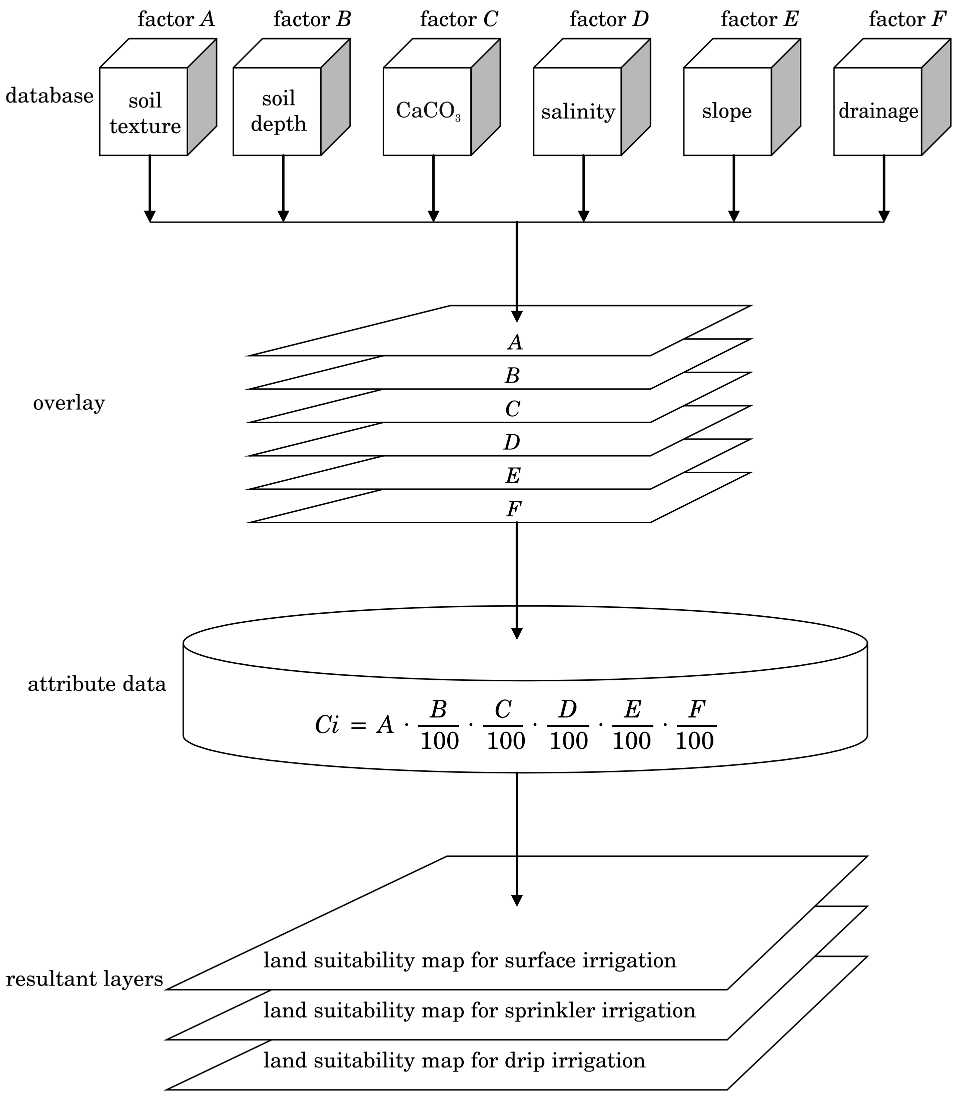

Fig. 3. Schematic chart of GIS application for land suitability map for different irrigation methods

Results and Discussion

As shown in Table 11 and Table 12 for surface irrigation, the soil series coded 5, 7 and 8 (18 804.64 ha – 37.9%) were highly suitable (S_1; Land having no, or insignificant limitations for irrigation); soil series coded 1, 2, 6, 9 and 11 (19 773.54 ha – 39.8%) were classified as moderately suitable (S_2; Land having minor limitations for irrigation), soil series coded 3, 4 and 12 (9925.16 ha – 20%) were found to be marginally suitable (S_3; land having moderate limitations for irrigation) and only soil series coded 10 (884.62 ha – 1.8%) were classified as currently not-suitable (N_1; land having severe limitations for irrigation) for any surface irrigation practices. There was no permanently not suitable land (N_2; land that have so severe limitations for irrigation) in this plain.

The analysis of the suitability irrigation maps for surface irrigation (Figure 4), indicate that the large parts of the cultivated area in this plain (located in the center and the north) is deemed as being highly suitable land due to deep soil, good drainage, texture, salinity and proper slope of the area. The moderately suitable lands could be observed over the largest portion of the plain (west, east, center and south parts) due to the medium calcium carbonate content limitations (It is limitations due to amount of $CaC0_3$ of soil. If the soil's

Table 11

Ci values and suitability classes of surface, sprinkler and drip irrigation for each soil series

Codes of soil series	Surface irrigation		Sprinkler irrigation		Drip irrigation	
	Ci	suitability classes	*Ci*	suitability classes	*Ci*	suitability classes
1	71.17	S_{2_s}	75.02	S_{2_s}	68.4	S_{2_s}
2	65.81	S_{2_s}	81	S_1	76	S_{2_s}
3	49.95	S_{3_s}	67.12	S_{2_s}	68.4	S_{2_s}
4	55.5	S_{3_s}	70.2	S_{2_s}	66.5	S_{2_s}
5	83.36	S_1	85.5	S_1	76	S_{2_s}
6	78	S_{2_s}	80	S_1	70	S_{2_s}
7	87.75	S_1	90	S_1	80	S_1
8	83.36	S_1	85.5	S_1	76	S_{2_s}
9	78.97	$S_{2_{sn}}$	85.5	S_1	76	S_{2_s}
10	42.12	$N_{1_{snw}}$	52.65	$S_{3_{snw}}$	52	$S_{3_{sn}}$
11	78.97	$S_{2_{sw}}$	85.5	S_1	80	S_1
12	52.21	$S_{3_{sw}}$	57.37	$S_{3_{sw}}$	54.4	$S_{3_{sw}}$

Limiting factors for surface irrigation: s – calcium carbonate; w – drainage.
Limiting factors for sprinkler and drip irrigations: s – calcium carbonate.

Table 12

Distribution of surface, sprinkler and drip irrigation suitability

Suitability	Surface irrigation			Sprinkler irrigation			Drip irrigation		
	soil series	area [ha]	ratio [%]	soil series	area [ha]	ratio [%]	soil series	area [ha]	ratio [%]
S_1	5, 7, 8	18804.64	37.9	2, 5, 6, 7, 8, 9, 11	36046.49	72.6	7, 11	13584.85	27.3
S_2	1, 2, 6, 9, 11	19773.54	39.8	1, 3, 4	4151.37	8.4	1, 2, 3, 4, 5, 6, 8, 9	26613.01	53.7
S_3	3, 4, 12	9925.16	20	10, 12	9190.1	18.5	10, 12	9190.1	18.5
N_1	10	884.62	1.8	–	–	–	–	–	–
N_2	–	–	–	–	–	–	–	–	–
Mis land	–	234.09	0.5	–	234.09	0.5	–	234.09	0.5
Total	–	49 622.04	100	–	49 622.04	100	–	49 622.04	100

Miscellaneous land – hill, sand dune and river bed

$CaC0_3$ was between 25–50%, the limitation of calcium carbonate is medium for surface irrigation) and medium drainage limitations (It is limitations due to a ground water table. if ground water table located between 2 and 3 m, the limitation of drainage is medium). Other factors such as slope, depth, salinity and alkalinity have no influence on the suitability of the area whatsoever. The map also indicates that only some part of the cultivated area in this plain was evaluated as marginally suitable because of the high calcium carbonate content. The current non-suitable lands covered the smallest part of the plain. Because of high content of calcium carbonate and very sever drainage, salinity and alkalinity limitations. There was no permanently non-suitable land in this plain. For almost the total study area elements such as soil depth, soil texture and slope were not considered as limiting factors.

In order to verify the possible effects of different management practices, the land suitability for sprinkler and drip irrigation was evaluated (Table 11 and Table 12).

For sprinkler irrigation, soil series coded 2, 5–9 and 11 (36 046.49 ha – 72.6%) were highly suitable (S_1) while soil series coded 1, 3 and 4 (41 51.37 ha- 8.4%) were classified as moderately suitable (S_2). Further, soil series coded 10 and 12 (9190.1 ha – 18.5%) were found to be marginally suitable (S_3) for sprinkler irrigation.

Regarding sprinkler irrigation (Figure 5), the highly suitable area can be observed in the largest part of the cultivated zone in this plain (located in the north, center, west and the east) due to deep soil, good drainage, texture,

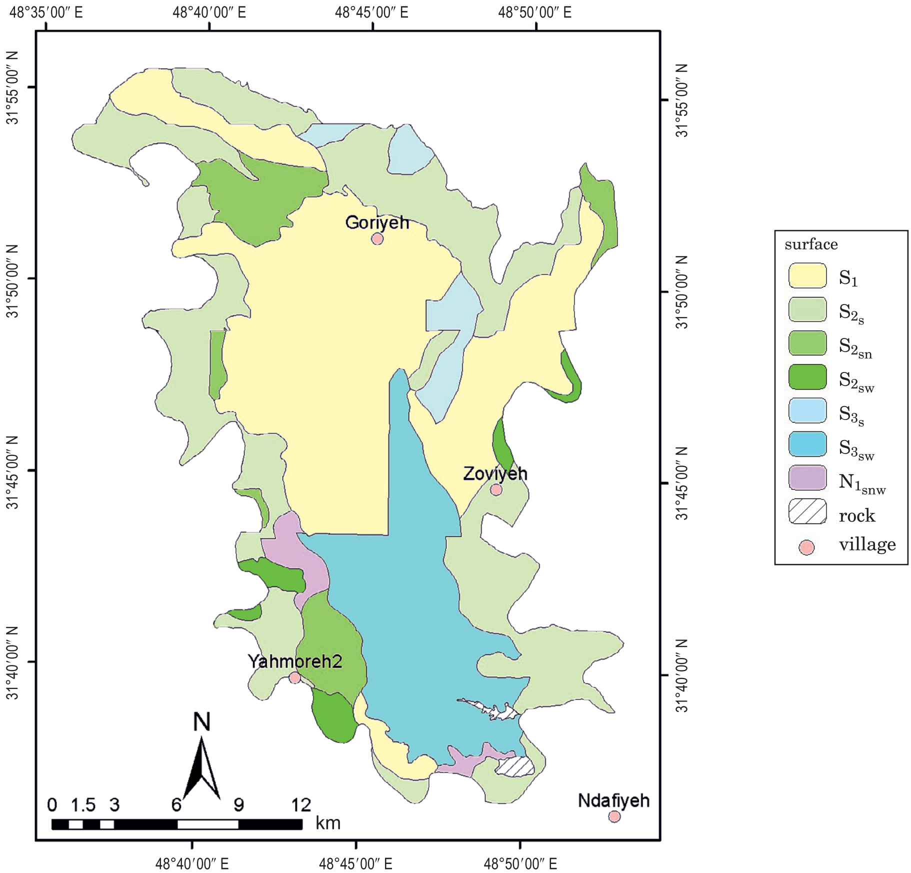

Fig. 4. Land suitability map for surface irrigation: S_1, S_{2_s}, $S_{2_{sn}}$, $S_{2_{sw}}$ – highly suitable; S_{3_s}, $S_{3_{sw}}$ – marginally suitable; $N_{1_{snw}}$ – currently not suitable

salinity and proper slope of the area. As seen from the map, the smallest part of the cultivated area in this plain was evaluated as moderately suitable for sprinkler irrigation because of the medium calcium carbonate content. Other factors such as drainage, depth, salinity and slope never influence the suitability of the area. The marginally suitable lands were found only in the center and south of the area studied. The limiting factors for these soil series were high content of calcium carbonate and sever limitations of drainage, salinity and alkalinity. The current non-suitable lands and permanently not-suitable lands did not exist in this plain. For almost the entire study area slope, soil depth and soil texture were not as limiting factors.

For drip irrigation, soil series coded 7 and 11 (13 584.85 ha – 27.3%) were highly suitable (S_1) while soil series coded 1–9 (26 613.01 ha – 53.7%) were

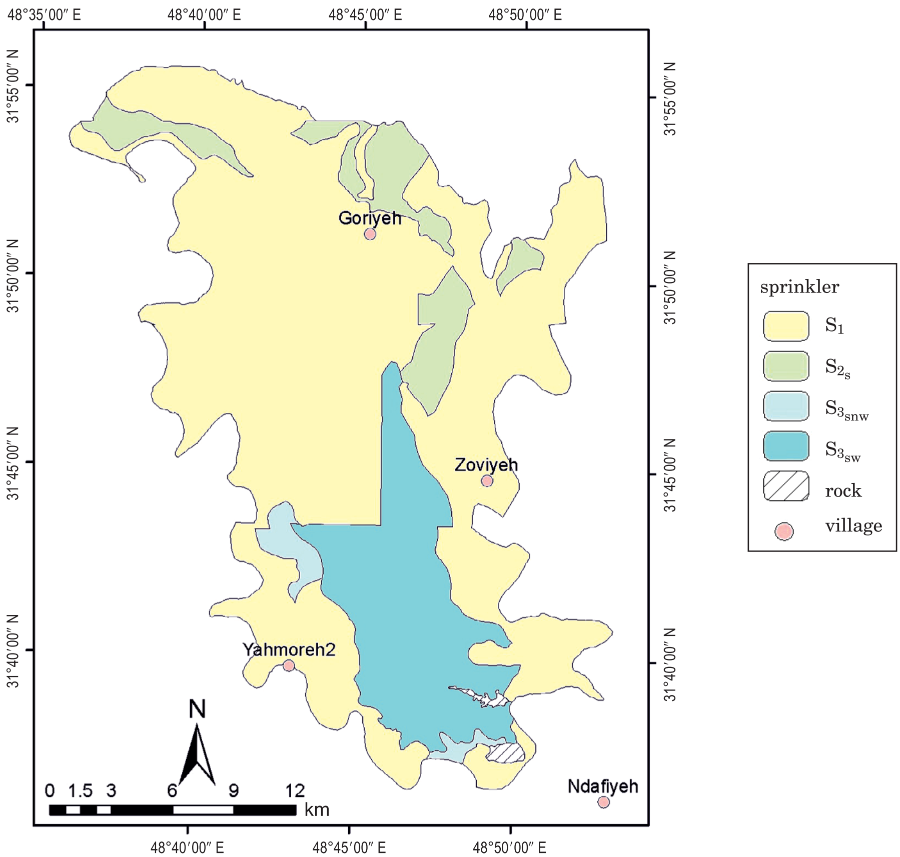

Fig. 5. Land suitability map for sprinkler irrigation: S_1 – highly suitable; S_{2_s} – moderately suitable; $S_{3_{snw}}$, $S_{3_{sw}}$ – marginally suitable

classified as moderately suitable (S_2) and further, soil series coded 10 and 12 (9190.1 ha, 18.5%) were found to be slightly suitable (S_3) for drip irrigation. In this case (Figure 6), the highly suitable area can be observed in the some part of the cultivated zone located in the center and east area. They were due to deep soil, good drainage, suitable texture, salinity and proper slope of the area. The largest portion of the cultivated area in the plain was evaluated as moderately suitable for drip irrigation; because of the medium calcium carbonate content. The map also indicated that the smallest portion of the cultivated area in this plain which is located in the south and center of the zone was evaluated as marginally suitable; due to the high calcium carbonate content and severe drainage, salinity and alkalinity limitations. The current non-suitable lands and permanently not-suitable lands do not exist in this plain. For almost the entire study area slope, soil depth and soil texture were not as limiting factors.

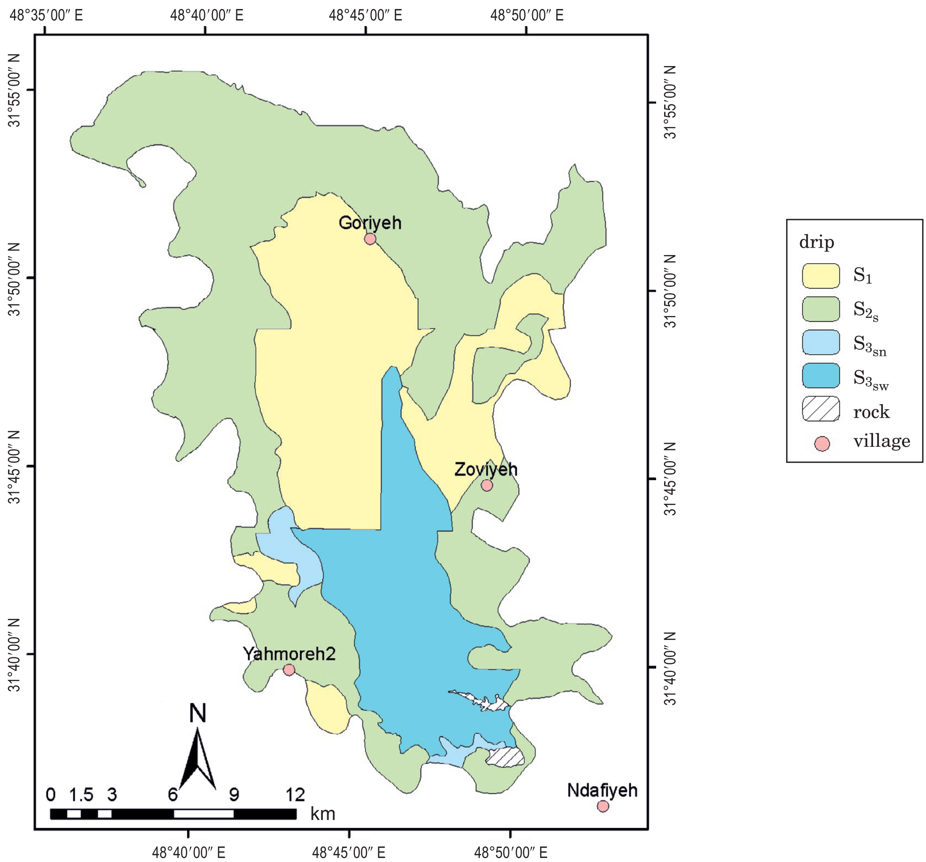

Fig. 6. Land Suitability Map for Drip Irrigation : S_1 – highly suitable; S_{2_s} – moderately suitable; $S_{3_{sn}}$, $S_{3_{sw}}$ – marginally suitable

The comparison of the capability indexes for surface, sprinkler and drip irrigation (Table 11 and Table 13) indicated that in soil series coded 3 applying drip irrigation systems was the most suitable option as compared to surface and sprinkler irrigation systems. In soil series coded 1–12 applying sprinkler irrigation systems was more suitable then surface and drip irrigation systems. Figure 7 shows the most suitable map for surface, sprinkler and drip irrigation systems in the Shoibieh Plain as per the capability index (*Ci*) for different irrigation systems. As seen from this map, the largest part of this plain was suitable for sprinkler irrigation systems and very small parts of this area was suitable for drip irrigation systems.

Table 13

The most suitable soil series for surface, sprinkler and drip irrigation systems by notation to capability index (*Ci*) for different irrigation systems

Codes of soil series	The maximum capability index for irrigation (*Ci*)	Suitability classes	The most suitable irrigation systems	Limiting factors
1	75.02	S_{2_s}	sprinkler	S
2	81	S_1	sprinkler	no exist
3	68.4	S_{2_s}	drip	S
4	70.2	S_{2_s}	sprinkler	S
5	85.5	S_1	sprinkler	no exist
6	80	S_1	sprinkler	no exist
7	90	S_1	sprinkler	no exist
8	85.5	S_1	sprinkler	no exist
9	85.5	S_1	sprinkler	no exist
10	52.65	$S_{3_{snw}}$	sprinkler	SNW
11	85.5	S_1	sprinkler	no exist
12	57.37	$S_{3_{sw}}$	sprinkler	SN

Limiting factors for sprinkler irrigations: S – calcium carbonate; N – salinity & alkalinity; W – drainage. Limiting factors for drip irrigation: S – calcium carbonate

The comparison between different irrigation systems (surface and pressurized systems) shows a big difference in the suitability of the different irrigation methods. Pressurized irrigation systems (sprinkler and drip irrigation systems) can be a good irrigation method, if properly managed (good planning, use of filters, etc) (BAVI et al. 2009, NASERI et al. 2009, ALBAJI et al. 2010b, ALBAJI et al. 2010c, DIOUF-SARR 2011, ALBAJI-HEMADI 2011, JOVZI et al. 2012, ALBAJI et al. 2013).

The results of Table 11 and Table 13 indicated that by applying sprinkler irrigation instead of surface and drip irrigation methods, the land suitability of 48 805, 43 ha (98.3%) of the Shoibieh Plain's land could be improved substantially. However by applying drip irrigation instead of surface and sprinkler irrigation methods, the suitability of 582, 53 ha (1.2%) of this Plain's land could be improved. The comparison of the different types of irrigation revealed that sprinkler irrigation was more effective and efficient then the drip and surface irrigation methods and improved land suitability for irrigation purposes. Moreover, the main limiting factors in using surface irrigation methods in this area were calcium carbonate content and drainage and the main limiting factor in using sprinkler and drip irrigation methods in this area was calcium carbonate content.

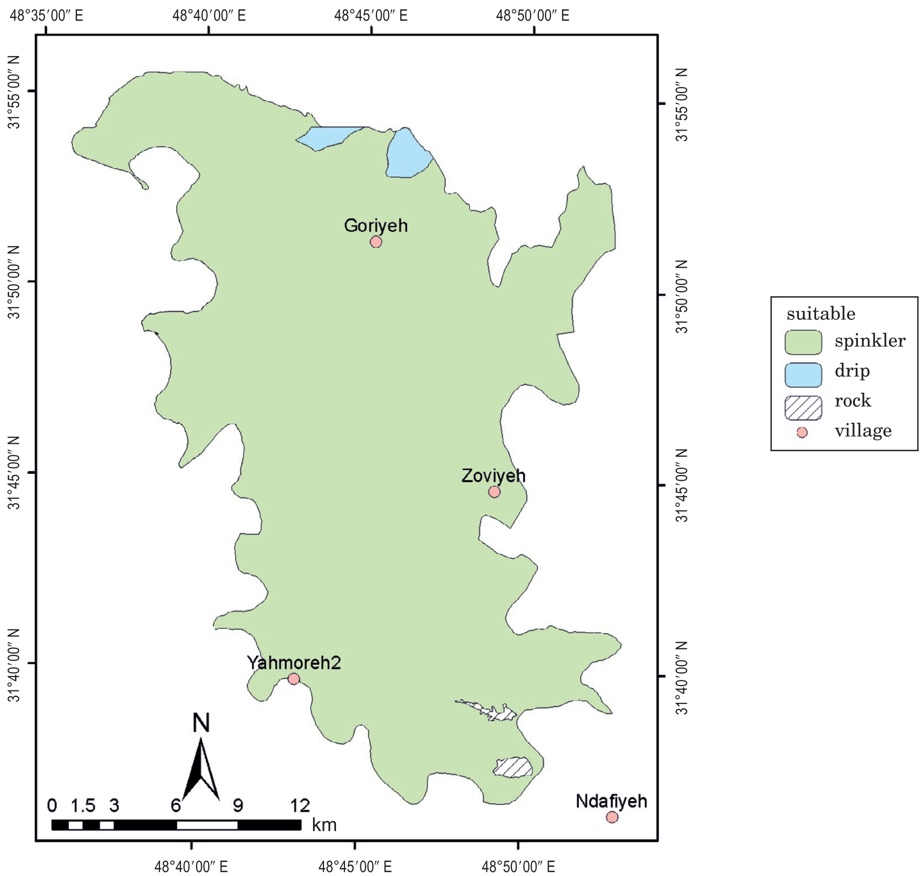

Fig. 7. The most suitable map for different irrigation systems

Conclusions

Several parameters were used for the analysis of the field data in order to compare the suitability of different irrigation systems. The analyzed parameters included soil and land characteristics. The results obtained showed that sprinkler irrigation systems are more suitable than drip and surface irrigation methods for most of the study area. The major limiting factor for both sprinkler and drip irrigation methods was soil calcium carbonate content. However for surface irrigation method, soil calcium carbonate content and drainage were restricting factors. The results of the comparison between the maps indicated that the introduction of a different irrigation management policy would provide an optimal solution in as such that the application of sprinkler irrigation technique could provide beneficial and advantageous. This is the current strategy adopted by large companies cultivating in the area and it will provide to be economically viable for Farmers in the long run.

Such a change in irrigation management practices would imply the availability of larger initial capitals to farmers (different credit conditions, for example) as well as a different storage and market organization.

In this study, an attempt has been made to analyze and compare three irrigation systems by taking into account various soil and land characteristics. The results obtained showed that sprinkler irrigation methods are more suitable than drip and surface irrigation methods for most of the soils tested. Moreover, because of the insufficiency of surface and ground water resources, and the aridity and semi-aridity of the climate in this area, sprinkler irrigation methods are highly recommended for a sustainable use of this natural resource; hence, the changing of current irrigation methods from gravity (surface) to pressurized (sprinkler) in the study area are proposed.

Acknowledgements

The author should gratefully acknowledge the Shahid Chamran University, Khouzestan Science and Research Branch, Islamic Azad University of Ahvaz and the Research and Standards Office for Dam and Power Plant of Khuzestan Water and Power Authority (KWPA) for their financial support and assistance during the study and field visits (Grant No. 636410).

Accepted for print 7.04.2014

References

ALBAJI M. 2008. *Semi-detailed Soil Study Report of Shoibieh Plain, Iran*: pp. 25–186 (in Persian).

ALBAJI M., BOROOMAND NASAB S., KASHKOLI H.A., NASERI A.A. 2009a. *Comparison of different irrigation methods based on the parametric evaluation approach in the plain west of Shush, Iran.* Irrig and Drain, 59(5): 547–558.

ALBAJI M., NASERI A.A., PAPAN P., BOROOMAND NASAB S. 2009b. *Qualitative evaluation of land suitability for principal crops in the West Shoush Plain, Southwest Iran*. Bulgarian J. Agric. Sci., 15(2): 135–145.

ALBAJI M. 2010a. *Land Suitability Evaluation for sprinkler irrigation systems.* Khuzestan Water and Power Authority (KWPA). Ahwaz, Iran, pp. 18–42 (in Persian).

ALBAJI M., BOROOMAND NASAB S., NASERI A.A., JAFARI S. 2010b. *Comparison of different irrigation methods based on the parametric evaluation approach in Abbas plain, Iran.* J. Irrig. Drain. Eng., 136(2): 131–136.

ALBAJI M., SHAHNAZARI A., BEHZAD M., NASERI A.A., BOROOMAND NASAB S., GOLABI M. 2010c. *Comparison of different irrigation methods based on the parametric evaluation approach in Dosalegh plain, Iran.* Agric. Water Manag., 97(7): 1093–1098.

ALBAJI M., HEMADI J. 2011. *Investigations of different irrigation systems based on the parametric evaluation approach on the Dasht Bozorg Plain.* Transactions of the Royal Society of South Africa, 66(3): 163–169.

ALBAJI M., GOLABI M., BOROOMAND NASAB S., NAZARI ZADEH F. 2013. *Investigation of surface, sprinkler and drip irrigation methods based on the parametric evaluation approach in Jaizan Plain.* Journal of the Saudi Society of Agricultural Sciences (in press).

BAVI A., KASHKULI HA, BOROOMAND NASAB S., NASERI A.A., ALBAJI M. 2009. *Evaporation Losses from Sprinkler Irrigation Systems under Various Operating Conditions.* Journal of Applied Sciences, 9(3): 597–600.

BEHZAD M., ALBAJI M., PAPAN P., BOROOMAND NASAB S., NASERI A.A., BAVI A. 2009. *Qualitative evaluation of land suitability for principal crops in the gargar region, khuzestan province, southwest iran.* Asian J. Plant Sci., 8(1): 28–34.

BROU YAO B., WOLDEGIORGIS HISHE S. 2009. *Land Evaluation in Kilte Awulaelo District – Tigrayregion – Ethiopia.* 29th Course Professional Master „Geomatics and Natural Resources Evaluation" 3th Nov 2008 – 26 Jun 2009. IAO, Florence, Italy, pp. 128–133.

DIOUF O.C., SARR N.P. 2011. *Land Evaluation in Sant'Antioco Island – Southern Sardinia, Italy.* 31th Course Professional Master „Geomatics and Natural Resources Evaluation" 2th Nov 2010 – 28 Jun 2011. IAO, Florence, Italy, pp. 116–119.

DENGIZ O. 2006. A *Comparison of Different Irrigation Methods Based on the Parametric Evaluation Approach.* Turk J. Agric. For., 30: 21–29.

Food and Agriculture Organization of the United Nations (FAO). 1976. *A Framework for Land Evaluation.* Soil Bulletin 32. FAO, Rome, Italy, pp. 15–17.

GIZACHEW A.A., NDAO M. 2008. *Land Evaluation in the Enderta District – Tigray – Ethiopia.* 28th Course Professional Master „Geomatics and Natural Resources Evaluation" 5th Nov 2007 – 27 Jun 2008. IAO, Florence, Italy, pp. 107–111.

HARGREAVES H.G., MEKLEY G.P. 1998. *Irrigation fundamentals.* Water Resource Publication, LLC: 152–153.

JALALI S. 1997. *Bulletin No. 758,* Iranian Soil and Water Research Institute, Tehran, Iran, pp. 83–102.

JOVZI M., ALBAJI M., GHARIBZADEH A. 2012. *Investigating the suitability of lands for surface and under-pressure (Drip and Sprinkler) irrigation in Miheh Plain.* Res. J. Environ. Sci., 6(2): 51–61.

MAHJOOBI A., ALBAJI M., TORFI K. 2010. *Determination of heavy metal levels of kondok soils-haftgel.* Res. J. Environ. Sci., 4(3): 294–299.

NASERI A.A., REZANIA A.A., ALBAJI M. 2009. *Investigation of soil quality for different irrigation systems in Lali Plain, Iran.* Journal of Food, Agriculture and Environment, 7(3–4): 955–960.

OLSEN G.W. 1981. *Soils and the Environment.* Chapman & Hall, New York, pp. 37–39.

PAGE A.L., MILLER R.H., KEENEY D.R. 1992. *Methods of Soil Analysis.* Part II. *Chemical and mineralogical properties*. 2nd edn. SSSA Pub., Madison, WIS, USA, pp. 73–74.

Soil Survey Staff. 2008. *Keys to soil taxonomy.* USDA, Washington, DC, pp. 45-94.

SYS C., VAN RANST E., DEBAVEYE J. 1991. *Land Evaluation,* Part 1, *Principles in land evaluation and crop production calculations.* International Training Centre for Post-graduate Soil Scientists, University Ghent, pp. 19–98.

TORFI K. 2010. *Meteorology Report of Shoibieh Plain*, Iran, pp. 23–38 (in Persian).