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Comparison of Different Irrigation Methods Based on the Parametric Evaluation Approach in West North Ahwaz Plain

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1. Introduction

Food security and stability in the world greatly depends on the management of natural resources. 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). Consequently, available water resources will not be able to meet various demands in the near future and this will inevitably result into the seeking of newer lands for irrigation in order to achieve sustainable global food security. Land suitability, by definition, is the natural capability of a given land to support a defined use. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for a defined use.

According to FAO methodology (1976) land suitability is strongly related to "land qualities" including erosion resistance, water availability, and flood hazards which are in themselves immeasurable qualities. Since these qualities are derived from "land characteristics", such as slope angle and length, rainfall and soil texture which are measurable or estimable, it is advantageous to use the latter indicators in the land suitability studies, and then use the land parameters for determining the land suitability for irrigation purposes. Sys et al. (1991) suggested a parametric evaluation system for irrigation methods which was primarily based upon physical and chemical soil properties. In their proposed system, the factors affecting soil suitability for irrigation purposes can be subdivided into four groups:

- Physical properties determining the soil-water relationship in the soil such as permeability and available water content;
- Chemical properties interfering with the salinity/alkalinity status such as soluble salts and exchangeable Na;
- Drainage properties;
- Environmental factors such as slope.

Briza et al. (2001) applied a parametric system (Sys et al. 1991) to evaluate land suitability for both surface and drip irrigation in the Ben Slimane Province, Morocco, while no highly suitable areas were found in the studied area. The largest part of the agricultural areas was classified as marginally suitable, the most limiting factors being physical parameters such as slope, soil calcium carbonate, sandy soil texture and soil depth.

Bazzani and Incerti (2002) also provided a land suitability evaluation for surface and drip irrigation systems in the province of Larche, Morocco, by using parametric evaluation systems. The results showed a large difference between applying the two different evaluations. The area not suitable for surface irrigation was 29.22% of total surface and 9% with the drip irrigation while the suitable area was 19% versus 70%. Moreover, high suitability was extended on a surface of 3.29% in the former case and it became 38.96% in the latter. The main limiting factors were physical limitations such as the slope and sandy soil texture.

Bienvenue et al. (2003) evaluated the land suitability for surface (gravity) and drip (localized) irrigation in the Thies, Senegal, by using the parametric evaluation systems. Regarding surface irrigation, there was no area classified as highly suitable (S_1). Only 20.24% of the study area proved suitable (S_2, 7.73%) or slightly suitable (S_3, 12. 51%). Most of the study area (57.66%) was classified as unsuitable (N_2). The limiting factor to this kind of land use was mainly the soil drainage status and texture that was mostly sandy while surface irrigation generally requires heavier soils. For drip (localized) irrigation, a good portion (45.25%) of the area was suitable (S_2) while 25.03% was classified as highly suitable (S_1) and only a small portion was relatively suitable (N_1, 5 .83 %) or unsuitable (N_2, 5.83%). In the latter cases, the handicap was largely due to the shallow soil depth and incompatible texture as a result of a large amount of coarse gravel and/or poor drainage.

Mbodj et al. (2004) performed a land suitability evaluation for two types of irrigation i. e, surface irrigation and drip irrigation, in the Tunisian Oued Rmel Catchment using the suggested parametric evaluation. According to the results, the drip irrigation suitability gave more irrigable areas compared to the surface irrigation practice due to the topographic (slope), soil (depth and texture) and drainage limitations encountered with in the surface irrigation suitability evaluation.

Barberis and Minelli (2005) provided land suitability classification for both surface and drip irrigation methods in Shouyang county, Shanxi province, China where the study was carried out by a modified parametric system. The results indicated that due to the unusual morphology, the area suitability for the surface irrigation (34%) is smaller than the surface used for the drip irrigation (62%). The most limiting factors were physical parameters including slope and soil depth.

Dengize (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. The most important limiting factors for surface irrigation in study area were soil salinity, drainage and soil texture, respectively whereas, the major limiting factors for drip or localized irrigation were soil salinity and drainage.

Liu et al. (2006) evaluated the land suitability for surface and drip irrigation in the Danling County, Sichuan province, China, using a Sys's parametric evaluation system. For surface irrigation the most suitable areas (S_1) represented about (24%) of Danling

County, (33%) was moderately suitable (S_2), (%9) was classified as marginally suitable (S_3), (7%) of the area was founded currently not suitable (N_1) and (25%) was very unsuitable for surface irrigation due to their high slope gradient. Drip irrigation was everywhere more suitable than surface irrigation due to the minor environmental impact that it caused. Areas highly suitable for this practice covered 38% of Danling County; about 10% was marginally suitable (the steep dip slope and the structural rolling rises of the Jurassic period). The steeper zones of the study area (23%) were either approximately or totally unsuitable for such a practice.

Albaji et al. (2007) carried out a land suitability evaluation for surface and drip Irrigation in the Shavoor Plain, in Iran. The results showed that 41% of the area was suitable for surface irrigation ;50% of the area was highly recommend for drip irrigation and the rest of the area was not considered suitable for either irrigation method due to soil salinity and drainage problem.

Albaji et al. (2010a) 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.

Albaji et al. (2010b) investigated different irrigation methods based upon a parametric evaluation system in an area of 29,300 ha in the Abbas plain located in the Elam province, in the West of Iran. The results demonstrated that by applying sprinkler irrigation instead of surface and drip irrigation methods, the arability of 21,250 ha (72.53%) in the Abbas plain will improve.

Albaji et al. (2010c) also provided a land suitability evaluation for surface, sprinkle and drip irrigation systems in Dosalegh plain: Iran. The comparison of the different types of irrigation techniques revealed that the drip and sprinkler irrigations methods were more effective and efficient than that of surface irrigation for improved land productivity. However, the main limiting factor in using either surface or/and sprinkler irrigation methods in this area were soil texture, salinity, and slope, and the main limiting factor in using drip irrigation methods were the calcium carbonate content, soil texture and salinity.

Albaji and Hemadi (2011) evaluated the land suitability for different irrigation systems based on the parametric evaluation approach on the Dasht Bozorg Plain:Iran. The results showed that by applying sprinkle irrigation instead of drip and surface irrigation, the arability of 1611.6 ha (52.5%) on the Dasht Bozorg Plain will improve. In addition, by applying drip irrigation instead of sprinkle or surface irrigation, the land suitability of 802.4 ha (26.2%) on this plain will improve. Comparisons of the different types of irrigation systems revealed that sprinkle and drip irrigation were more effective and efficient than surface irrigation for improving land productivity. It is noteworthy, however, that the main limiting factor in using sprinkle and/or drip irrigation in this area is the soil calcium carbonate content and the main limiting factors in using surface irrigation are soil calcium carbonate content together with drainage.

The main objective of this research is to evaluate and compare land suitability for surface, sprinkle and drip irrigation methods based on the parametric evaluation systems for the West North Ahwaz Plain, in the Khuzestan Province, Iran.

2. Materials and methods

The present study was conducted in an area about 37324.91 hectares in the West north ahwaz Plain, in the Khuzestan Province, located in the West of Iran during 2009-2011. The study area is located 5 km West north of the city of Ahwaz, 31^{o} 20´ to 31 ^{o} 40´ N and 48 ^{o} 36´ to 48^{o} 47´ E. The Average annual temperature and precipitation for the period of 1965-2004 were 24.5 C^{o} and 210 mm, respectively. Also, the annual evaporation of the area is 2,550 mm (Khuzestan Water & Power Authority [KWPA], 2005). 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. Currently, the irrigation systems used by farmlands in the region are furrow irrigation, basin irrigation and border irrigation schemes.

The area is composed of two distinct physiographic features i.e. River Alluvial Plains and Plateaux, of which the River Alluvial Plains physiographic unit is the dominating features. Also, twenty two different soil series were found in the area (Table.1).

The semi-detailed soil survey report of the West north ahwaz plain (KWPA. 2009) was used in order to determine the soil characteristics. Table.2 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. The topographic characteristics included slope and soil properties such as soil texture, depth, salinity, drainage and calcium carbonate content were taken into account. 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) 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.

Based upon the profile description and laboratory analysis, the groups of soils that had similar properties and were located in a same physiographic unit, were categorized as soil series and were taxonomied to form a soil family as per the Keys to Soil Taxonomy (2008). Ultimately, twenty two soil series were selected for the surface, sprinkle and drip irrigation land suitability.

In order to obtain the average soil texture, salinity and $CaCo_3$ for the upper 150cm of soil surface, 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).

For the evaluation of land suitability for surface, sprinkle 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.

Six parameters including slope, drainage properties, electrical conductivity of soil solution, calcium carbonates status, soil texture and soil depth were also considered and rates were assigned to each as per the related tables, thus, the capability index for irrigation (Ci) was developed as shown in the equation (1):

$$Ci = A \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{F}{100} \tag{1}$$

where A, B, C, D, E, and F are soil texture rating, soil depth rating, calcium carbonate content rating, electrical conductivity rating, drainage rating and slope rating, respectively.

Series No	Characteristics description
1	Soil texture " Heavy : *CL", without salinity and alkalinity limitation, Depth 150 cm, level to very gently sloping : 0 to 2%, imperfectly drained.
2	Soil texture " Heavy : CL", very severe salinity and alkalinity limitation, Depth 100 cm, level to very gently sloping : 0 to 2%, poorly drained.
3	Soil texture " Medium : SL", without salinity and alkalinity limitation, Depth 150 cm, level to very gently sloping : 0 to 2%, moderately drained.
4	Soil texture " Heavy : SIC", without salinity and alkalinity limitation, Depth 120 cm, level to very gently sloping : 0 to 2%, imperfectly drained.
5	Soil texture " Medium : SL", without salinity and alkalinity limitation, Depth 150 cm, level to very gently sloping : 0 to 2%, moderately drained.
6	Soil texture " Very Heavy: C", slight salinity and alkalinity limitation, Depth 125 cm, level to very gently sloping : 0 to 2%, poorly drained.
7	Soil texture " Very Heavy : SIC", very severe salinity and alkalinity limitation , Depth 140cm, level to very gently sloping : 0 to 2%, very poorly drained.
8	Soil texture" Very Heavy: C", severe salinity and alkalinity limitation, Depth 150cm, level to very gently sloping : 0 to 2%, very poorly drained.
9	Soil texture" Heavy: SICL", without salinity and alkalinity limitation, Depth 110 cm, level to very gently sloping : 0 to 2%, poorly drained.
10	Soil texture" Very Heavy: C", severe salinity and alkalinity limitation, Depth 150 cm, level to very gently sloping : 0 to 2%, very poorly drained.
11	Soil texture " Very Heavy : C", very severe salinity and alkalinity limitation, Depth 110 cm, level to very gently sloping : 0 to 2%, very poorly drained.
12	Soil texture " Medium : L", without salinity and alkalinity limitation, Depth 170 cm, level to very gently sloping : 0 to 2%, moderately drained.
13	Soil texture " Heavy : SICL", without salinity and alkalinity limitation, Depth 150 cm, level to very gently sloping : 0 to 2%, well drained.
14	Soil texture " Very Heavy : SIC", moderate salinity and alkalinity limitation, Depth 150 cm, level to very gently sloping : 0 to 2%, imperfectly drained.
15	Soil texture " Heavy: SICL", without salinity and alkalinity limitation, Depth 135 cm, level to very gently sloping : 0 to 2%, well drained.
16	Soil texture" Heavy: SICL",very without salinity and alkalinity limitation, Depth 150cm, level to very gently sloping : 0 to 2%, well drained.
17	Soil texture" Heavy: SCL", without salinity and alkalinity limitation, Depth 150 cm, level to very gently sloping : 0 to 2%, well drained.
18	Soil texture " Medium: SIL", slight salinity and alkalinity limitation, Depth 135 cm, level to very gently sloping : 0 to 2%, well drained.
19	Soil texture " Heavy : SICL", without salinity and alkalinity limitation , Depth 140cm, level to very gently sloping : 0 to 2%, well drained.
20	Soil texture" Heavy: SICL", without salinity and alkalinity limitation, Depth 150cm, level to very gently sloping : 0 to 2%, well drained.
21	Soil texture " Medium : SIL", slight salinity and alkalinity limitation, Depth 140 cm, level to very gently sloping : 0 to 2%, well drained.
22	Soil texture " Heavy : SICL", slight salinity and alkalinity limitation, Depth 130 cm, level to very gently sloping : 0 to 2%, well drained.

* Texture symbols: LS: Loamy Sand, SL: Sandy Loam, L: Loam , SIL: Silty Loam , CL: Clay Loam , SICL: Silty Clay Loam , SCL: Sandy Clay Loam , SC: Sandy Clay , SIC: Silty Clay , C: Clay.

Table 1. Soil series of the study area.

Soil seris.No	Soil seris.name	Depth (Cm)	Soil texture	ECe ($ds.m^{-1}$)	pH	OM (%)	CEC (meq/100g)	$CaCo_3$ (%)
1	Veyss	150	CL	1.50	7.90	0.24	8.54	48.00
2	Omel Gharib	100	CL	48.00	7.70	0.46	5.61	49.00
3	Ramin	150	SL	1.10	7.80	0.39	8.19	41.00
4	Amerabad	120	SIC	3.50	8.50	0.23	10.31	48.00
5	Solieh	150	SL	3.40	7.90	0.29	5.57	34.00
6	Band Ghir	125	C	4.10	8.00	0.52	15.24	35.00
7	Abu Baghal	140	SIC	52.00	8.10	0.37	11.43	45.00
8	Sheykh Mussa	150	C	17.50	8.40	0.56	13.26	46.00
9	Safak	110	SICL	3.90	8.10	0.47	13.53	40.00
10	Molla Sani	150	C	21.50	7.90	0.36	12.91	39.00
11	Teal Bomeh	110	C	55.00	7.90	0.68	9.85	49.00
12	Karkheh	170	L	2.70	7.70	0.29	6.49	46.00
13	Karun 1	150	SICL	2.20	7.70	0.25	9.21	47.00
14	Shoteyt	150	SIC	9.50	7.90	0.60	8.66	47.00
15	Abbasieh 1	140	SICL	1.10	7.60	0.39	8.63	51.00
16	Deylam 1	150	SICL	2.90	7.50	0.28	10.48	50.00
17	Qalimeh	150	SCL	1.20	7.90	0.26	12.05	49.00
18	Abbasieh 2	135	SIL	5.90	7.60	0.39	12.73	44.00
19	Karun 2	140	SICL	1.00	7.60	0.41	10.22	51.00
20	Deylam 2	150	SICL	3.40	7.50	0.32	10.81	49.00
21	Ghaleh Nasir	140	SIL	4.20	7.60	0.38	11.56	51.00
22	Abdul Amir	130	SICL	7.50	7.80	0.57	10.38	46.00

Table 2. Some of physico – chemical characteristics for reference profiles of different soil series.

In Table 3 the ranges of capability index and the corresponding suitability classes are shown.

Capability Index	Definition	Symbol
> 80	Highly Suitable	S1
60-80	Moderately Suitable	S2
45-59	Marginally Suitable	S3
30-44	Currently Not Suitable	N1
< 29	Permanently Not Suitable	N2

Table 3. Suitability Classes for the Irrigation Capability Indices (Ci) Classes.

In order to develop land suitability maps for different irrigation methods (Figs.2-5), a semi-detailed soil map (Fig.1) 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 twenty two different polygons or land mapping units (LMU) were determined in the base map. Soil characteristics were also given for each LMU. These values were used to generate the land suitability maps for surface, sprinkle and drip irrigation systems using Geographic Information Systems.

3. Results and discussion

Over much of the West north ahwaz Plain, the use of surface irrigation systems has been applied specifically for field crops to meet the water demand of both summer and winter crops .The major irrigated broad-acre crops grown in this area are wheat, barley, and maize, in addition to fruits , melons, watermelons and vegetables such as tomatoes and cucumbers. There are very few instances of sprinkle and drip irrigation on large area farms in the West north ahwaz Plain.

Twenty two soil series and eighty six series phases or land units were derived from the semi-detailed soil study of the area(Table.1). The land units are shown in Fig.1 as the basis for further land evaluation practice. The soils of the area are of Aridisols and Entisols orders. Also, the soil moisture regime is Aridic and Aquic while the soil temperature regime is Hyperthermic (KWPA.2003).

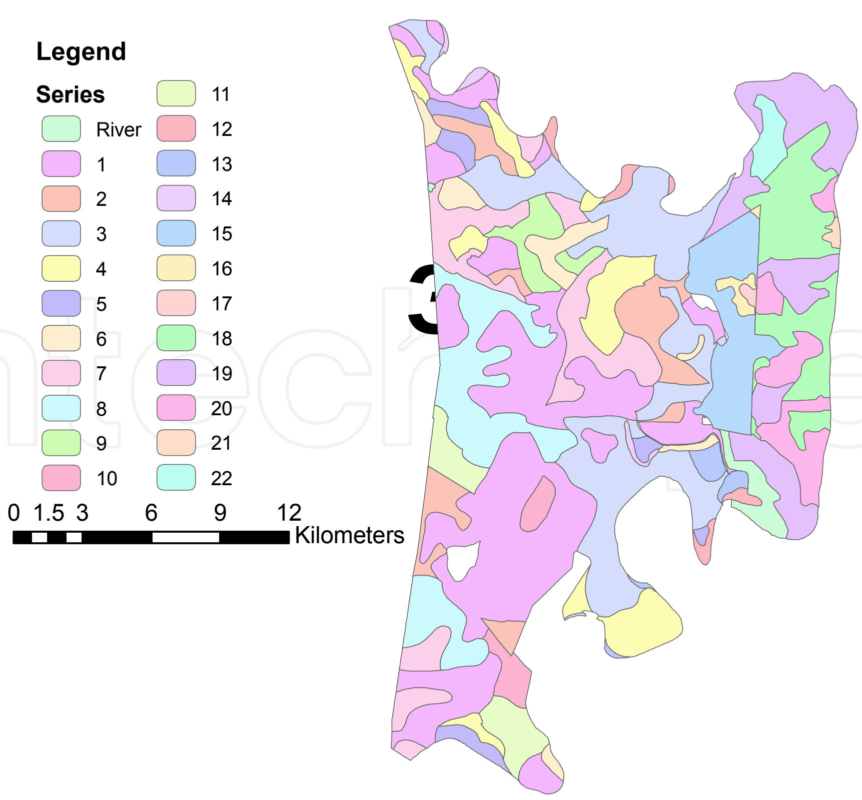

Fig. 1. Soil Map of the Study Area.

As shown in Tables 4 and 5 for surface irrigation, the soil series coded 13, 16, 17, 18 and 20 (4233.46 ha – 11.36%) were highly suitable (S_1); soil series coded 1, 12, 15, 19, 21 and 22 (14041.96 ha – 37.62 %) were classified as moderately suitable (S_2), soil series coded 3, 4, 5 and 9 (8835.99 ha – 23.66%) were found to be marginally suitable (S_3). soil series coded 6 and 14 (1033.86 ha – 2.77%) were classified as currently not-suitable (N_1) and soil series coded 2, 7, 8, 10 and 11 (8714.66 ha – 23.34 %) were classified as permanently not-suitable (N_2) for any surface irrigation practices.

The analysis of the suitability irrigation maps for surface irrigation (Fig. 2) indicate that some portion of the cultivated area in this plain (located in the east) is deemed as being highly suitable land due to deep soil, good drainage, texture, salinity and proper slope of the area. The moderately suitable area is mainly located to the center, and east of this area due to soil texture and drainage limitations. Other factors such as depth and slope have no influence on the suitability of the area whatsoever. The map also indicates that some part of the cultivated area in this plain was evaluated as marginally suitable because of the

Codes of Land Units	Surface Irrigation		Sprinkle Irrigation		Drip Irrigation	
	Ci	suitability classes	Ci	suitability classes	Ci	suitability classes
1	70.2	S2 sw [a]	76.5	S2 sw [b]	72	S2 sw [c]
2	11.40	N2 snw	12.6	N2 snw	12.8	N2 snw
3	59.23	S3 sw	76.95	S2 s	76	S2 s
4	52.21	S3 sw	57.37	S3 sw	54.4	S3 sw
5	59.23	S3 sw	76.95	S2 s	76	S2 s
6	40.27	N1snw	47.23	S3 sw	45.22	S3 sw
7	17.90	N2 snw	22.37	N2 snw	22.1	N2 snw
8	20.88	N2 snw	25.81	N2 snw	25.5	N2 snw
9	52.65	S3 sw	58.5	S3 sw	56	S3 sw
10	20.88	N2 snw	25.81	N2 snw	25.5	N2 snw
11	17.90	N2 snw	22.37	N2 snw	22.1	N2 snw
12	71.07	S2 sw	76.95	S2 s	72	S2 S
13	87.75	S1	90	S1	80	S1
14	41.76	N1snw	48.76	S3 snw	46.24	S3 snw
15	78	S2 s	80	S1	70	S2 S
16	87.75	S1	90	S1	80	S1
17	83.36	S1	85.5	S1	76	S2 S
18	83.36	S1	85.5	S1	76	S2 S
19	78	S2 S	80	S1	70	S2 S
20	87.75	S1	90	S1	80	S1
21	74.1	S2 s	76	S2 S	66.5	S2 S
22	78.97	S2 sn	85.5	S1	76	S2 S

a & b . Limiting Factors for Surface and Sprinkle Irrigations: n: (Salinity & Alkalinity), w: (Drainage) and s: (Soil Texture).
c. Limiting Factors for Drip Irrigation: s: (Calcium Carbonate & Soil Texture), w: (Drainage) and n: (Salinity & Alkalinity).

Table 4. Ci Values and Suitability Classes of Surface ,Sprinkle and Drip irrigation for Each Land Units.

drainage and soil texture limitations. The current non-suitable land and permanently non-suitable land can be observed only in the west and center of the plain because of very severe limitation of salinity & alkalinity, drainage and soil texture. For almost the total study area elements such as soil depth, slope and $CaCO_3$ were not considered as limiting factors.

In order to verify the possible effects of different management practices, the land suitability for sprinkle and drip irrigation was evaluated (Tables 4 and 5).

For sprinkle irrigation, soil series coded 13, 15, 16, 17, 18, 19, 20 and 22 (9329.14 ha – 25.01%) were highly suitable (S_1) while soil series coded 1, 3, 5, 12 and 21 (14938.7 ha- 40.02%) were classified as moderately suitable (S_2). Further, soil series coded 4, 6, 9 and 14 (3877.43 ha – 10.38%) were found to be marginally suitable (S_3) and soil series coded 2, 7, 8, 10 and 11 (8714.66 ha – 23.34 %) were classified as permanently not-suitable (N_2) for sprinkle irrigation.

Suitability	Surface Irrigation			Sprinkle Irrigation			Drip Irrigation		
	Land unit	Area (ha)	Ratio (%)	Land unit	Area (ha)	Ratio (%)	Land unit	Area (ha)	Ratio (%)
S1	13 , 16 , 17 , 18 , 20	4233.46	11.36	13 , 15 , 16 , 17 , 18 , 19 , 20 , 22	9329.14	25.01	13 , 16 , 20	1724.88	4.64
S2	1 , 12 , 15 , 19 , 21 , 22	14041.96	37.62	1 , 3 , 5 , 12 , 21	14938.7	40.02	1 , 3 , 5 , 12 , 15 , 17 , 18 , 19 , 21 , 22	22542.96	60.39
S3	3 , 4 , 5 , 9	8835.99	23.66	4 , 6 , 9 , 14	3877.43	10.38	4 , 6 , 9 , 14	3877.43	10.38
N1	6 , 14	1033.86	2.77	-	-	-	-	-	-
N2	2 , 7 , 8 , 10 , 11	8714.66	23.34	2 , 7 , 8 , 10, 11	8714.66	23.34	2 , 7 , 8 , 10 , 11	8714.66	23.34
[a]Mis Land		464.99	1.25		464.99	1.25		464.99	1.25
Total		37324.91	100		37324.91	100		37324.91	100

a. Miscellaneous Land: (Hill, Sand Dune and River Bed)

Table 5. Distribution of Surface, Sprinkle and Drip Irrigation Suitability.

Regarding sprinkler irrigation, (Fig. 3) the highly suitable area can be observed in the some part of the cultivated zone in this plain (located in the east) due to deep soil, good drainage, texture, salinity and proper slope of the area. As seen from the map, the largest part of the cultivated area in this plain was evaluated as moderately suitable for sprinkle irrigation because of the moderate limitations of drainage and soil texture. Other factors such as depth, salinity and slope never influence the suitability of the area. The marginally suitable lands are located only in the North and south of the plain. The permanently non-suitable land can be observed in the west and center of the plain and their non-suitability of the land are due to the severe limitations of salinity & alkalinity, drainage and soil texture. The current non-suitable lands did not exist in this plain. For almost the entire study area slope, soil depth and $CaCO_3$ were never taken as limiting factors.

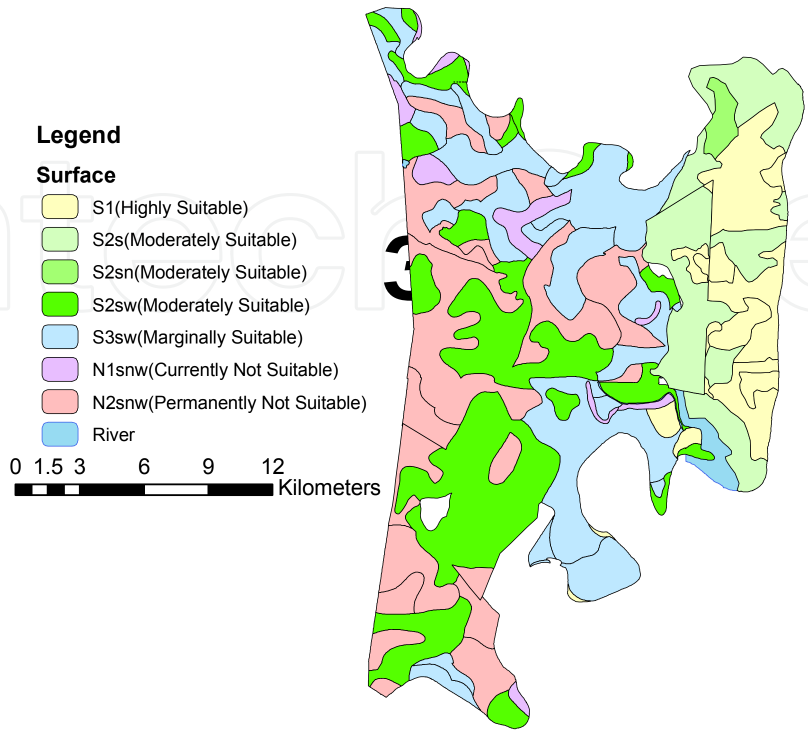

Fig. 2. Land Suitability Map for Surface Irrigation.

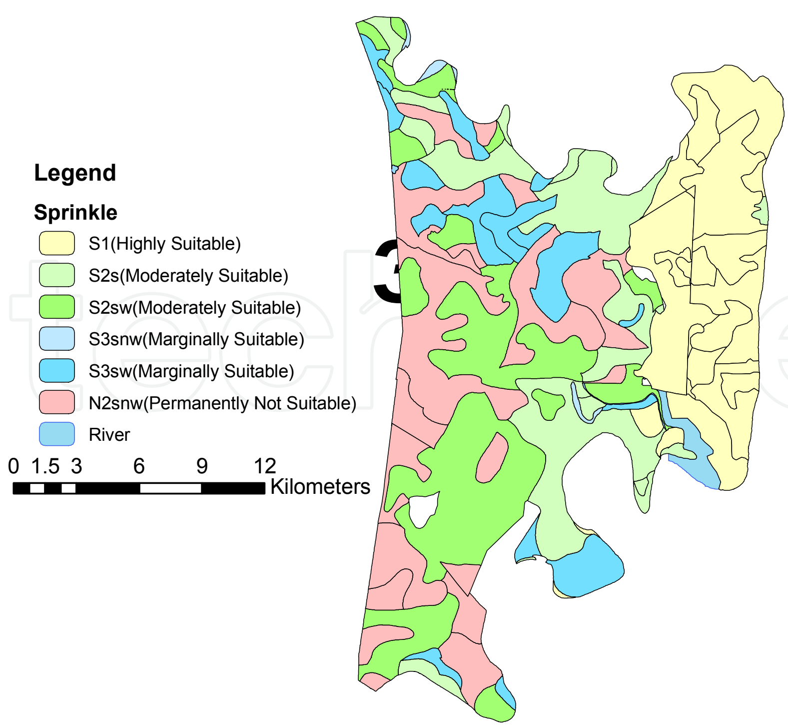

Fig. 3. Land Suitability Map for Sprinkle Irrigation.

For drip irrigation, soil series coded 13, 16 and 20 (1724.88 ha-4.64%) were highly suitable (S_1) while soil series coded 1, 3, 5, 12, 15, 17, 18, 19, 21 and 22 (22542.96 ha- 60.39%) were classified as moderately suitable (S_2). Further, soil series coded 4, 6, 9 and 14 (3877.43 ha, 10.38%) were found to be slightly suitable (S_3) and soil series coded 2, 7, 8, 10 and 11 (8714.66 ha – 23.34 %) were classified as permanently not-suitable (N_2) for drip irrigation.

Regarding drip irrigation, (Fig. 4) the highly suitable lands covered the smallest part of the plain. The slope, soil texture, soil depth, calcium carbonate, salinity and drainage were in good conditions .The moderately suitable lands could be observed over a large portion of the plain (east, north and south parts) due to the medium content of calcium carbonate. The marginally suitable lands were found only in the Northwest and southeast of the area .The limiting factors for this land unit were drainage and the medium content of calcium carbonate. The permanently non-suitable land can be observed in the west and center of the plain and their non-suitability of the land are due to the severe limitations of calcium carbonate, salinity & alkalinity, drainage and soil texture. The current non-suitable lands did not exist in this plain. For almost the entire study area slope, soil depths were never taken as limiting factors.

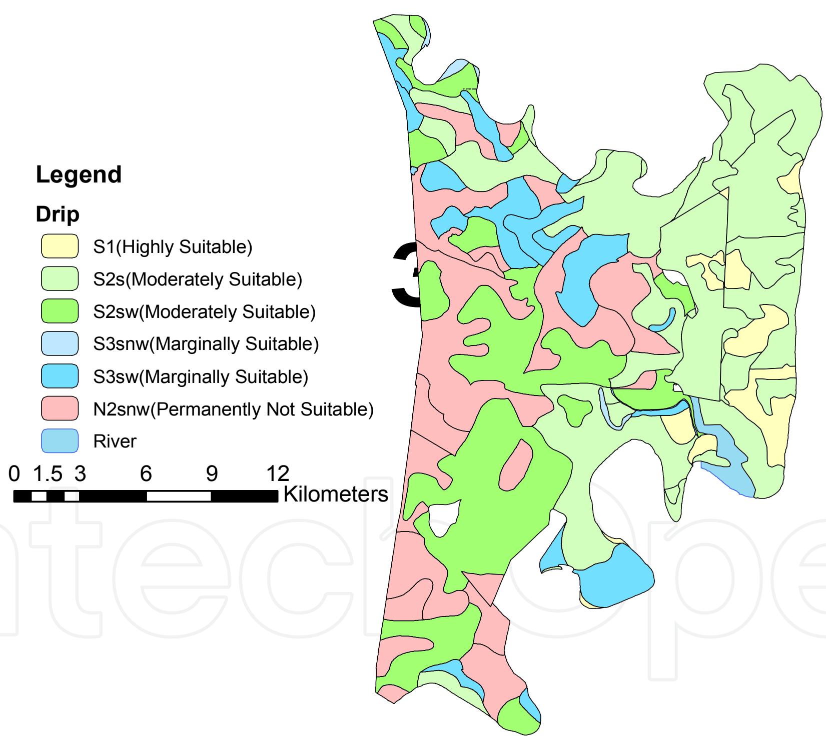

Fig. 4. Land Suitability Map for Drip Irrigation.

The mean capability index (Ci) for surface irrigation was 55.90 (Marginally suitable) while for sprinkle irrigation it was 62.33 (Moderately suitable). Moreover, for drip irrigation it was 58.31 (Marginally suitable). For the comparison of the capability indices for surface, sprinkle and drip irrigation. Tables 6 indicated that in soil series coded 2 applying drip irrigation systems was the most suitable option as compared to surface and sprinkle irrigation systems. In soil series coded 1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21 and 22 applying sprinkle irrigation systems was more suitable then surface and drip irrigation systems. Fig.5 shows the most suitable map for surface, sprinkle and drip irrigation systems in the West north ahwaz 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 sprinkle irrigation systems and some parts of this area was suitable for drip irrigation systems.

The results of Tables 4, 5 and 6indicated that by applying sprinkle irrigation instead of surface and drip irrigation methods, the land suitability of 35038,81 ha (93.87%) of the west north ahwaz Plain's land could be improved substantially. However by applying drip Irrigation instead of surface and sprinkle irrigation methods, the suitability of 1821,12 ha (4.88%) of this Plain's land could be improved. The comparison of the different types of irrigation revealed that sprinkle irrigation was more effective and efficient then the drip and surface irrigation methods and improved land suitability for irrigation purposes. The second best option was the application of drip irrigation which was considered as being more practical than the surface irrigation method. To sum up the most suitable irrigation systems for the west north ahwaz Plain' were sprinkle irrigation, drip irrigation and surface irrigation respectively. Moreover, the main limiting factor in using surface and sprinkle irrigation methods in this area were salinity & alkalinity, drainage and soil texture and the main limiting factors in using drip irrigation methods were the salinity & alkalinity, drainage, soil texture and calcium carbonate.

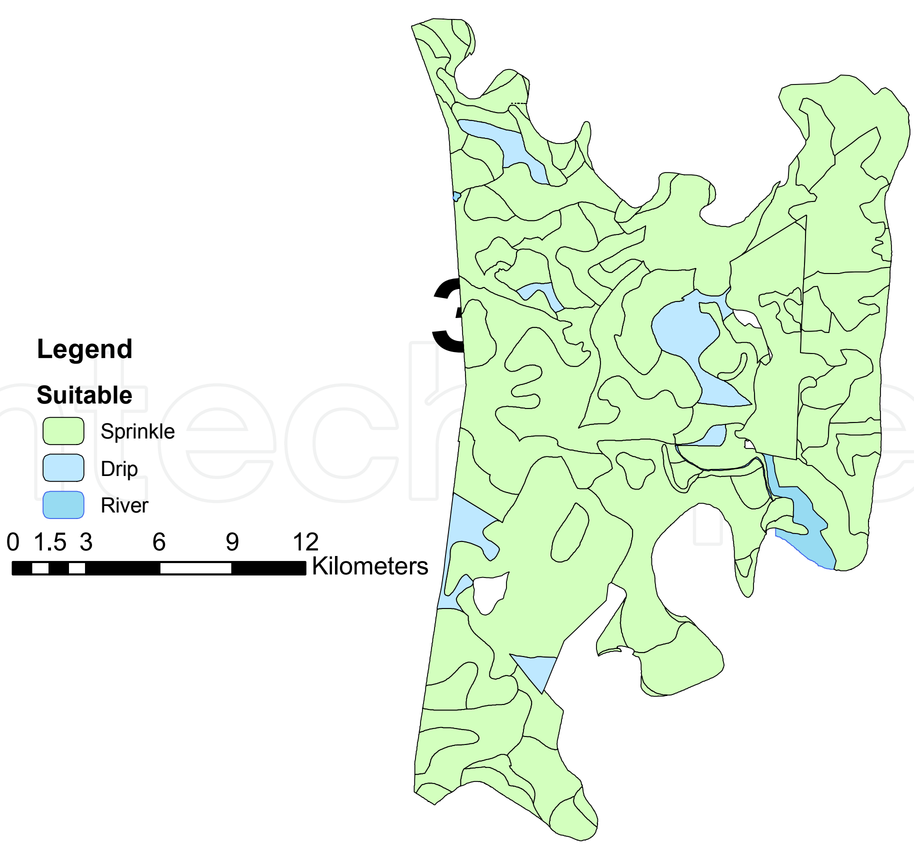

Fig. 5. The most suitable map for different irrigation systems.

Codes of Land Units	The Maximum Capability Index for Irrigation(Ci)	Suitability Classes	The Most Suitable Irrigation Systems	Limiting Factors
1	76.5	S2 sw	Sprinkle	Soil Texture and Drainage
2	12.8	N2 snw	Drip	CaCo3& Soil Texture, Salinity & Alkalinity and Drainage
3	76.95	S2 s	Sprinkle	Soil Texture
4	57.37	S3 sw	Sprinkle	Soil Texture and Drainage
5	76.95	S2 s	Sprinkle	Soil Texture
6	47.23	S3 sw	Sprinkle	Soil Texture and Drainage
7	22.37	N2 snw	Sprinkle	Soil Texture , Salinity & Alkalinity and Drainage
8	25.81	N2 snw	Sprinkle	Soil Texture , Salinity & Alkalinity and Drainage
9	58.5	S3 sw	Sprinkle	Soil Texture and Drainage
10	25.81	N2 snw	Sprinkle	Soil Texture , Salinity & Alkalinity and Drainage
11	22.37	N2 snw	Sprinkle	Soil Texture , Salinity & Alkalinity and Drainage
12	76.95	S2 s	Sprinkle	Soil Texture
13	90	S1	Sprinkle	No Exist
14	48.76	S3 snw	Sprinkle	Soil Texture , Salinity & Alkalinity and Drainage
15	80	S1	Sprinkle	No Exist
16	90	S1	Sprinkle	No Exist
17	85.5	S1	Sprinkle	No Exist
18	85.5	S1	Sprinkle	No Exist
19	80	S1	Sprinkle	No Exist
20	90	S1	Sprinkle	No Exist
21	76	S2s	Sprinkle	Soil Texture
22	85.5	S1	Sprinkle	No Exist

Table 6. The Most Suitable Land Units for Surface, Sprinkle and Drip Irrigation Systems by Notation to Capability Index (Ci) for Different Irrigation Systems.

4. 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 sprinkle and drip irrigation systems are more suitable than surface irrigation method for most of the study area. The major limiting factor for both sprinkle and surface irrigation methods were salinity & alkalinity, drainage and soil texture. However for drip irrigation method, salinity & alkalinity, drainage, soil texture and calcium carbonate 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 sprinkle and drip irrigation techniques 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. On the other hand, because of the insufficiency of water in arid and semi arid climate, the optimization of water use efficiency is necessary to produce more crops per drop and to help resolve water shortage problems in the local agricultural sector. The shift from surface irrigation to high-tech irrigation technologies, e.g. sprinkle and drip irrigation systems, therefore, offers significant water-saving potentials. On the other hand, since sprinkle and drip irrigation systems typically apply lesser amounts of water (as compared with surface irrigations methods) on a frequent basis to maintain soil water near field capacity, it would be more beneficial to use sprinkle and drip irrigations methods in this plain.

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 sprinkle and drip irrigation methods are more suitable than surface or gravity irrigation method 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, sprinkle and drip 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 (sprinkle and drip) in the study area are proposed.

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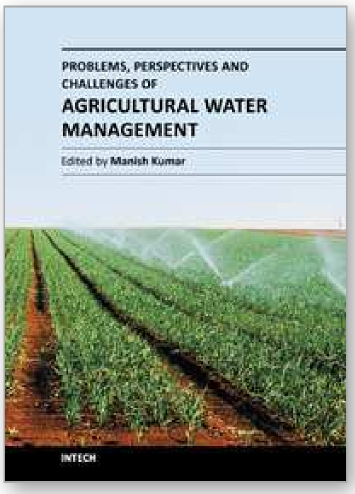

Problems, Perspectives and Challenges of Agricultural Water Management
Edited by Dr. Manish Kumar

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Food security emerged as an issue in the first decade of the 21st Century, questioning the sustainability of the human race, which is inevitably related directly to the agricultural water management that has multifaceted dimensions and requires interdisciplinary expertise in order to be dealt with. The purpose of this book is to bring together and integrate the subject matter that deals with the equity, profitability and irrigation water pricing; modelling, monitoring and assessment techniques; sustainable irrigation development and management, and strategies for irrigation water supply and conservation in a single text. The book is divided into four sections and is intended to be a comprehensive reference for students, professionals and researchers working on various aspects of agricultural water management. The book seeks its impact from the diverse nature of content revealing situations from different continents (Australia, USA, Asia, Europe and Africa). Various case studies have been discussed in the chapters to present a general scenario of the problem, perspective and challenges of irrigation water use.

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