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Land suitability evaluation for different irrigation systems in Zaviehha plain, Iran

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ABSTRACT

The main objective of this research was to compare different irrigation methods based upon a parametric evaluation system in an area of 3770 ha in the Zaviehha plain located in the Khuzestan Province, in the south-west of Iran. The soil properties of the study area such as texture, depth, electrical conductivity, drainage, calcium carbonate content and slope were derived from a semi-detailed soil study carried out on the Zaviehha plain on a scale of 1 : 20000. Once the soil properties were analyzed and evaluated, suitability maps were generated for surface, sprinkle and drip irrigation methods using Remote Sensing (RS) Techniques and Geographic Information System (GIS). The obtained results showed that for 705 ha (18.7%) of the study area surface irrigation method was highly recommended, whereas for 908.2 ha (24.1%) of the study area sprinkle and drip irrigation methods would provide to be extremely efficient and suitable; moreover, it was found that 808.7 ha (21.4%) of the study area was incompatible for drip and surface irrigation methods; however, for sprinkle irrigation systems, the unsuitable lands did not exist in this zone. The results demonstrated that by applying sprinkle irrigation instead of drip and surface irrigation methods, the arability of 2090.2 ha (55.5%) in the Zaviehha Plain will improve. In addition by applying drip irrigation instead of sprinkle and surface irrigation methods, the land suitability of 1651.8 ha (43.8%) of this plain will improve. The comparison of the different types of irrigation techniques revealed that the sprinkle and drip irrigation methods were more effective and efficient than the surface irrigation method for improving land productivity. It is of note, however, that the main limiting factors in using surface irrigation method in this area were soil texture and drainage and the main limiting factor in using sprinkle irrigation method was soil texture. Also, the major limiting factors in using drip irrigation method were the soil's calcium carbonate content and texture.

Key words : Drip irrigation, land suitability evaluation, parametric method, soil series, sprinkle irrigation, surface irrigation

INTRODUCTION

Food security and stability in the world greatly depend 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 in 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.

Dengize (2006) 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

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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 found 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.* (2008) 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 recommended for drip irrigation and the rest of the area was not considered suitable for either irrigation method due to soil salinity and drainage problem.

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 Zaviehha Plain, in the Khuzestan Province, Iran.

MATERIALS AND METHODS

The present study was conducted in an area about 3770 hectares in the Zaviehha Plain, in the Khuzestan Province, located in the south-west of Iran (Fig. 1) during 2007-08. The study area is located 10 km west of the city of Dezful, 32°15′ to 32°22′ N and 48°16′ to 48°22′ E. The average annual temperature and precipitation for the period 1965-2004 were 24.1°C and 371 mm, respectively. Also, the annual evaporation of the area was 2521 mm (KWPA, 2005). The Dez 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 one distinct physiographic feature i. e. Gravelly Alluvial Fans. Also, seven different soil series were found in the area. The semi-detailed soil survey report of the Zaviehha plain (KWPA, 2003) was used in order to determine the soil characteristics. The land evaluation was determined based upon topography and soil characteristics of the region. The topographic

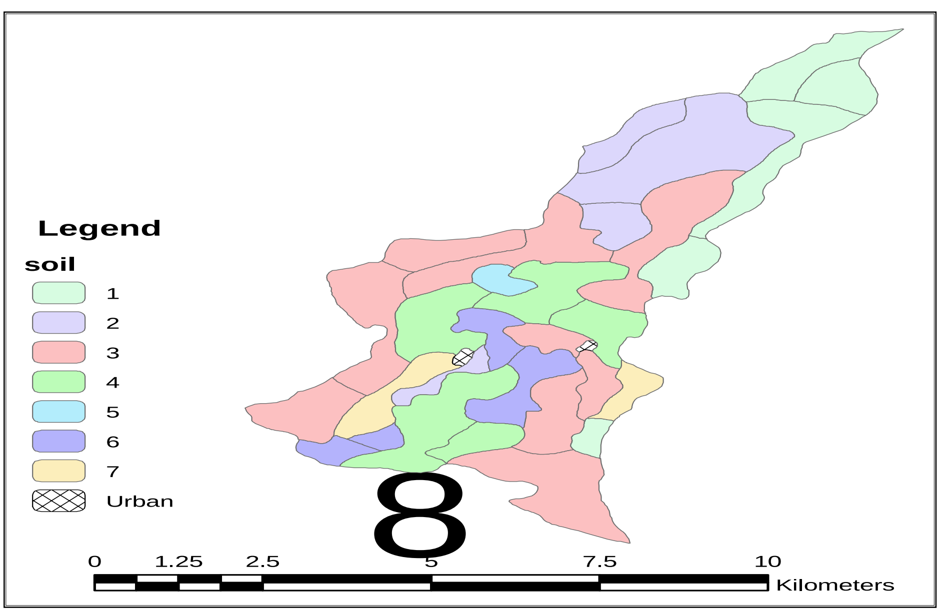

Fig. 1. Soil map of the study area.

characteristics including 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 (2000). Ultimately, seven 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 150 cm of soil surface, the profile was sub-divided into six 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 below :

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

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. In Table 1, the ranges of capability index and the corresponding suitability classes are shown.

Table 1. 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

RESULTS AND DISCUSSION

Seven soil series or land units and 28 series phases were derived from the semi-detailed soil study of the area. The land units are shown in Fig.1 as the basis for further land evaluation practice. The soils of the area are of Entisols order. Also, the soil moisture regime is Ustic, while the soil temperature regime is Hyperthermic (KWPA, 2003).

As shown in Tables 2 and 3 for surface irrigation, only soil series coded 4 (705 ha–18.7%) were highly suitable (S_1); soil series coded 5, 6 and 7 (576.5 ha–15.4%) were classified as moderately suitable (S_2), and soil series coded 2 and 3 (1651.8 ha–43.8%) were found to be marginally suitable (S_3). Only soil series coded 1 (808.7 ha–21.4%) were classified as currently not-suitable (N_1) for any surface irrigation practices.

The analysis of the suitability irrigation maps for surface irrigation (Fig. 2) indicates that the some portion of the cultivated area in this plain (located in the center and south) 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 located in the smallest part of this area due to moderate soil texture and drainage limitation. Other factors such as depth, salinity and alkalinity have no influence on the suitability of the area whatsoever. The map also indicates that the biggest portion of the cultivated area in this plain was evaluated as marginally suitable because of the loamy sand soil texture. The current non-suitable land can be observed only in the north and east of the plain because of physical limitations especially gravelly soil texture. There was no permanently non-suitable land in this plain. For almost the total study area, elements such as soil depth, slope, salinity and $CaCO_3$ were not considered as limiting factors.

Table 2. Ci values and suitability classes of surface, sprinkle and drip irrigation for each land unit

Codes of land units	Surface irrigation		Sprinkle irrigation		Drip irrigation	
	Ci	Suitability classes	Ci	Suitability classes	Ci	Suitability classes
1	39.48	N_{1S}*	45.00	$S_{3\,s}$**	44.00	$N_{1\,s}$***
2	57.03	S_{3S}	67.50	$S_{2\,s}$	68.00	$S_{2\,s}$
3	57.03	S_{3S}	67.50	S_{2S}	68.00	S_{2S}
4	87.75	S_1	90.00	S_1	80.00	S_1
5	78.97	S_{2SW}	85.50	S_1	80.00	S_1
6	70.20	$S_{2\,s}$	72.00	$S_{2\,s}$	64.00	$S_{2\,s}$
7	70.20	S_{2SW}	81.00	S_1	80.00	S_1

*Limiting factors for surface irrigation : $_s$: (Soil texture) and $_w$ (Drainage).
**Limiting factors for sprinkle irrigation : $_s$: (Soil texture).
***Limiting factors for drip irrigation : $_s$: (Soil texture and calcium carbonate).

Table 3. Distribution of surface, sprinkle and drip irrigation suitability

Suitability	Surface irrigation			Sprinkle irrigation			Drip irrigation		
	Land unit	Area (ha)	Ratio (%)	Land unit	Area (ha)	Ratio (%)	Land unit	Area (ha)	Ratio (%)
S_1	4	705	18.7	4 , 5 , 7	908.2	24.1	4 , 5 , 7	908.2	24.1
S_2	5 , 6 , 7	576.5	15.4	2 , 3 , 6	2025.1	53.8	2 , 3 , 6	2025.1	53.8
S_3	2 , 3	1651.8	43.8	1	808.7	21.4	-	-	-
N_1	1	808.7	21.4	-	-	-	1	808.7	21.4
N_2	-	-	-	-	-	-	-	-	-
*Mis. land		28	0.7		28	0.7		28	0.7
Total		3770	100		3770	100		3770	100

*Miscellaneous land (Hill, sand dune and river bed).

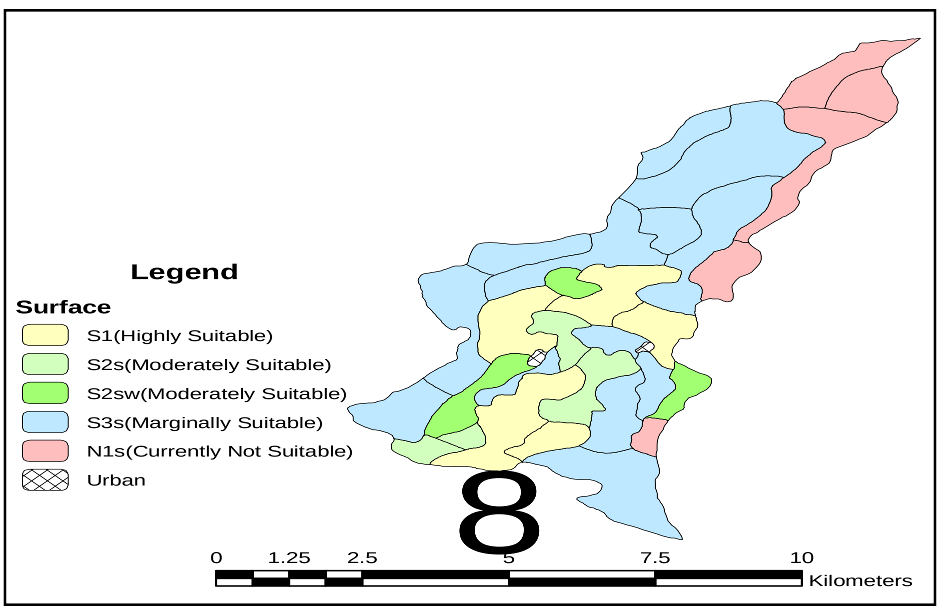

Fig. 2. Land suitability map for surface irrigation.

In order to verify the possible effects of different management practices, the land suitability for sprinkle and drip irrigation was evaluated (Tables 2 and 3).

For sprinkle irrigation, soil series coded 4, 5 and 7 (908.2 ha – 24.1%) were highly suitable (S_1), while soil series coded 2, 3 and 6 (2025.1 ha–53.8%) were classified as moderately suitable (S_2). Only soil series coded 1 (808.7 ha–21.4%) was classified as marginal suitable (S_3). Further, there was not found unsuitable lands (N_1) for sprinkle irrigation.

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

For drip irrigation, soil series coded 4, 5 and 7 (908.2 ha–24.1%) were highly suitable (S_1), while soil series coded 2, 3 and 6 (2025.1 ha–53.8%) were classified as moderately suitable (S_2). There was not found lands with marginal suitability (S_3) in this plain. Moreover, only soil series coded 1 (808.7 ha–21.4%) were found to be currently non-suitable (N_1) for drip irrigation.

Regarding drip irrigation (Fig. 4), the highly suitable lands covered some 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 the largest portion of the plain (West, East and South parts) due to the medium content of calcium carbonate and loamy sand soil texture. The current non-suitable lands were found only in the north

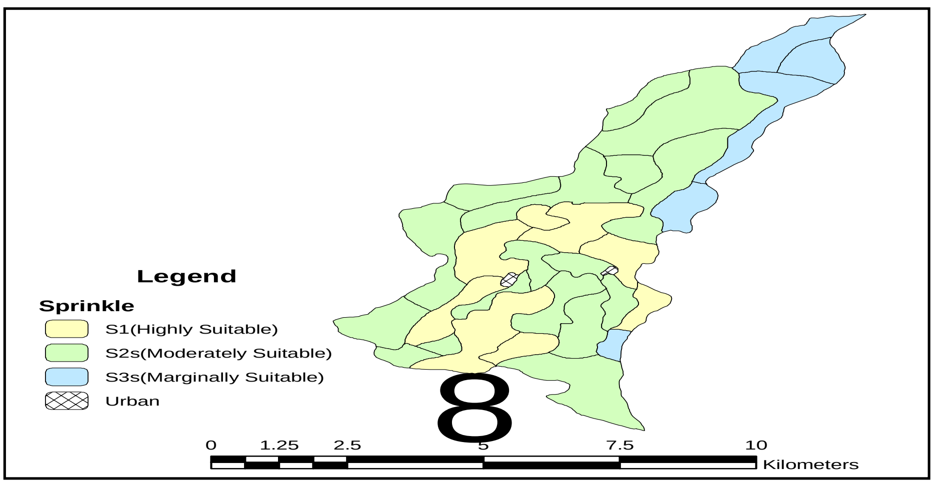

Fig. 3. Land suitability map for sprinkle irrigation.

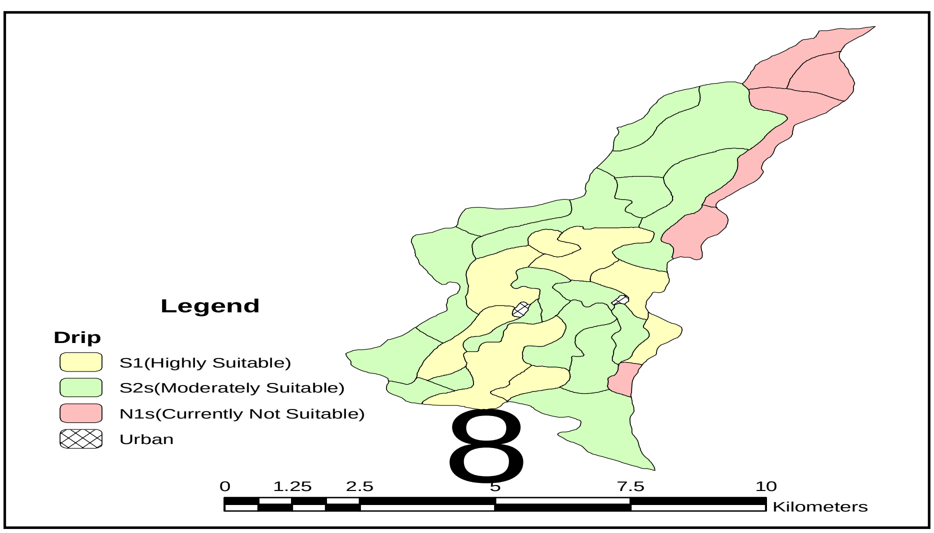

Fig. 4. Land suitability map for drip irrigation.

and east of the area. The limiting factors for this land unit were gravelly soil texture and the medium content of calcium carbonate. The marginally suitable lands and permanently non-suitable land did not exist in this plain. For the entire study area, slope, soil depth, drainage and salinity were never considered as limiting factors.

The mean capability index (Ci) for surface irrigation was 61.15 (moderately suitable), while for sprinkle irrigation it was 68.10 (moderately suitable). Moreover, for drip irrigation it was 65.32 (moderately suitable). Tables 2 and 4 indicate that in soil series coded 7, 2 and 3 applying drip irrigation systems was more suitable than sprinkle and surface irrigation systems. In soil series coded 1, 4, 5, 6 and 7 applying sprinkle irrigation systems was the most suitable option as compared to drip and surface irrigation systems. Fig. 5 shows the most suitable map for surface, sprinkle and drip irrigation systems in the Zaviehha 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 were suitable for drip irrigation systems.

Table 4. The most suitable land units for surface, sprinkle and drip irrigation systems by notation to capability index (Ci) 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	45.00	S_{3s}	Sprinkle	Soil texture
2	68.00	S_{2s}	Drip	$CaCO_3$ and soil texture
3	68.00	S_{2s}	Drip	$CaCO_3$ and soil texture
4	90.0	S_1	Sprinkle	No Exist
5	85.50	S_1	Sprinkle	No Exist
6	72.00	S_{2s}	Sprinkle	Soil texture
7	81.00	S_1	Sprinkle	No Exist

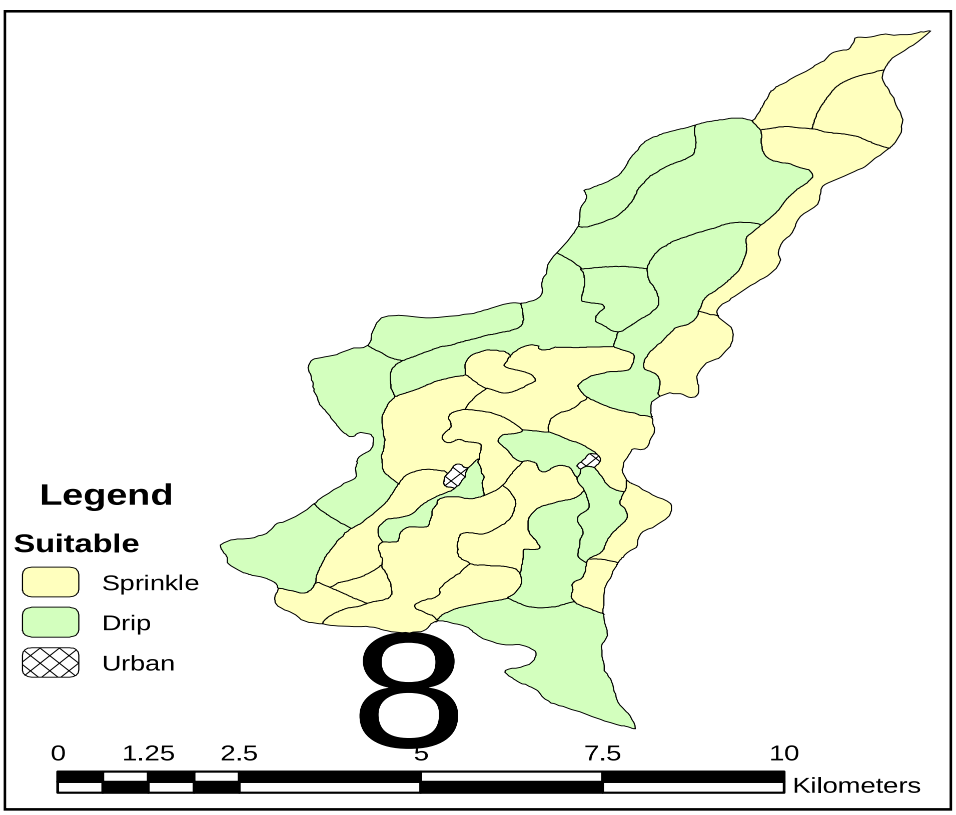

Fig. 5. The most suitable map for different irrigation systems.

CONCLUSIONS

The results in Tables 2 and 4 indicate that by applying sprinkle irrigation instead of drip and surface irrigation methods, the land suitability of 2090.2 ha (55.5%) of the Zaviehha Plain's land could be improved substantially. However, by applying drip irrigation instead of sprinkle and surface irrigation methods, the suitability of 1651.8 ha (43.8%) of this Plain's land could be improved. The application of surface irrigation instead of sprinkle and drip irrigation methods would not provide land suitability improvement in this zone. The comparison of the different types of irrigation revealed that sprinkle irrigation was more effective and efficient than 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 Zaviehha Plain' were sprinkle irrigation, drip irrigation and surface irrigation, respectively. Moreover, the main limiting factors in using surface irrigation method in this area were soil texture and drainage and the main limiting factor in using sprinkle irrigation method was soil texture. Also, the major limiting factors in using drip irrigation method were the soil's calcium carbonate content and texture.

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REFERENCES

Albaji, M., Landi, A., Boroomand Nasab, S. and Moravej, K. (2008). Land suitability evaluation for surface and drip irrigation in Shavoor Plain, Iran. *J. Appl. Sci.* **8** : 654-59.

Dengize, O. (2006). A comparison of different irrigation methods based on the parametric evaluation approach. *Turk. J. Agric For.* **30** : 21-29. *http://journals.tubitak.gov.tr/agriculture/issues/tar-06-30-1/tar-30-1-3-0505-15.pdf.*

Hargreaves, H. G. and Mekley, G. P. (1998). *Irrigation Fundamentals.* Water Resource Publication, LLC. 200 pp.

Keys to Soil Taxonomy (2000). U. S. Department of Agriculture. By Soil Survey Staff, Washington, DC, USA. *http://www.statlab.iastate.edu/soils/ keytax.*

Khuzestan Water and Power Authority (KWPA) (2003). Semi-detailed Soil Study Report of Zaviehha Plain, Iran (in Persian). *http://www.kwpa.com.*

Khuzestan Water and Power Authority (KWPA) (2005). Meteorology Report of Zaviehha Plain, Iran (in Persian). *http://www.kwpa.com.*

Liu, W., Qin, Y. and Vital, L. (2006). Land evaluation in Danling county, Sichuan province, China. 26th Course Professional Master. Geometric and Natural Resources Evaluation, 7th Nov 2005–23rd June 2006. IAO. Florence, Italy. *http://www.iao.florence.it/training/geomatics/Danling/China_26.pdf.*

Sys, C., Van Ranst, E . and Debaveye, J. (1991). Land evaluation. Part l. Principles in land evaluation and crop production calculations. International Training Centre for Post-graduate Soil Scientists, University Ghent. *http://www.plr.ugent.be/publicatie.html.*