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Land Suitability Evaluation for Surface, Sprinkle and Drip Irrigation Methods in Fakkeh Plain, Iran

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Abstract: The main objective of this research is to compare different irrigation methods based upon a parametric evaluation system in an area of 43700 ha in the Fakkeh region located in Elam Province, West Iran. Soil properties of the study area including texture, depth, electrical conductivity, drainage, calcium carbonate content and slope were derived from a semi-detailed soil study regarding Fakkeh plain in a scale of 1:20000. After analyzing and evaluating soil properties, suitability maps were generated for surface, sprinkle and drip Irrigation methods by means of Remote Sensing (RS) Technique and Geographic Information System (GIS). The results showed that 1715 ha (3.93%) of the studied area were highly suitable for surface irrigation method whereas 7365 ha (16.86%) of the study area highly suitable for sprinkle irrigation methods. Also, it was found that 28190 ha (64.51%) of the study area were highly suitable for drip irrigation methods while some land units coded 1.1, 7.1 and 4.1 covering an area of 9335 ha (21.36%) were not suitable to be used for surface irrigation systems and one land unit coded 7.1 with an area of 735 ha (1.68%) was classified as unsuitable for sprinkle and drip irrigation systems. The results demonstrated that by applying drip irrigation method instead of surface and sprinkle irrigation methods, land suitability classes of 36790 ha (84.19%) for Fakkeh Plain will improve. Also, by applying sprinkle Irrigation instead of surface and drip irrigation methods, land suitability classes of 6945 ha (15.89%) of this plain will improve. The comparison of the different types of irrigation techniques revealed that the drip irrigation was more effective and efficient than the surface and sprinkle irrigation methods for improving the suitability to the irrigation purposes. Also, the sprinkle irrigation was more useful than surface irrigation method. Additionally, the main limiting factor in using surface and sprinkle irrigation methods in this area was soil texture and the main limiting factor in using drip irrigation methods was soil calcium carbonate content.

Key words: Surface irrigation, sprinkle irrigation, drip irrigation, land suitability evaluation, parametric method, land units

INTRODUCTION

Food security and stability in the world greatly depends on the management of the natural resources. Due to depletion of water resources and an increase in population, irrigated area per capita is declining and irrigated lands now produce 40% of the food supply (Hargreaves and Mekley, 1998). Consequently, the available water resources may not be able to meet various demands in near future that will inevitably result in the irrigation of additional lands in order to achieve a sustainable global food security. The 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 the FAO methodology (1976), this is strongly related to the land qualities including erosion resistance, water availability and flood hazards that are not measurable qualities. As these qualities are derived from the 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. Thus, the land parameters are used to obtain 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

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proposed system, the factors affecting the 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, the highly 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, using the parametric evaluation system proposed by Sys *et al*. (1991). Under 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 almost suitable (N_1, 5 .83%) or unsuitable (N_2, 5.83%). In the latter cases, the handicap is given by the shallow soil depth and incompatible texture due to 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 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.

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. 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 the 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 Jurassic). Only the steeper relieves of the study area (23%) were almost or very unsuitable for such a practice.

Albaji *et al*. (2007) investigated land suitability evaluation for surface and drip Irrigation in Shavoor Plain, Iran. The results showed that 41% of the area were suitable for surface irrigation, 50% of the area were highly recommend for drip irrigation and the rest of area were not suitable for the both irrigation method due to soil salinity and drainage problem.

Albaji *et al*. (2007) compared different irrigation methods based on the parametric evaluation approach in west Shoush Plain, Iran. The results showed that 9031 ha (21.52%) of the studied area were highly suitable for surface irrigation method whereas 32505 ha (77.47%) of the study area were highly suitable for drip irrigation method. Moreover, by applying drip irrigation method instead of surface irrigation method, land suitability classes of 30128 ha (71.81%) of west Shoush Plain will improve. Ultimately, drip irrigation system was suggested as the best method to be applied to the study area. The main limiting factors in using surface irrigation method in this area were sandy soil texture and slope, also for drip irrigation methods the main limiting factor was soil calcium carbonate.

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 Fakkeh Plain, Elam Province, Iran.

MATERIALS AND METHODS

The present study was conducted in an area about 43700 ha in Fakkeh Plain, Elam Province, west of Iran during 2007. The study area is located 80 km southwest the city of Andimeshk, 32° 01′ to 32° 13′ N and 47° 32′ to 47° 57′ E. Average annual temperature and precipitation for the period of 1965-2004 were 24.1°C and 230 mm, respectively. Also, the annual evaporation of the area is 1950 mm (KWPA, 2005). The main water supply to this area is Dowayrej River. The study area has been commonly used for irrigated agriculture. Presently, the irrigation systems used by farmlands are furrow irrigation, basin irrigation and border irrigation schemes.

The area is composed of two distinct physiographic features i.e. Plateaux and Flood Plains, where Plateaux physiographic units are the dominating features. Also, seven different soil series were found in the area. The semi-detailed soil survey report of Fakkeh Plain was used in order to determine the soil characteristics (KWPA, 2003). The land evaluation was determined based upon topography and soil characteristics of the region. The topographic characteristics included slope while soil properties included soil texture, depth, salinity, drainage and calcium carbonate content. 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 the arid regions while clay CEC rate usually exceeds the plant requirement without further limitation, thus, fertility properties can be excluded from land evaluation with the purpose of irrigation.

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

Based upon the profile description and laboratory analysis, the group of soils that had similar properties and located in a same physiographic unit were considered as a series of soils 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 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 to surface 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.

RESULTS AND DISCUSSION

In much of the Fakkeh Plain, the surface irrigation system has been applied specifically for field crops to meet water needs of both summer and winter crops .The major irrigated broad-acre crops grown in this area are wheat, barley, fruits including melon, watermelon and vegetables, such as tomato and cucumber. There are very few instances of sprinkle and drip irrigation on large area farms in the Fakkeh Plain.

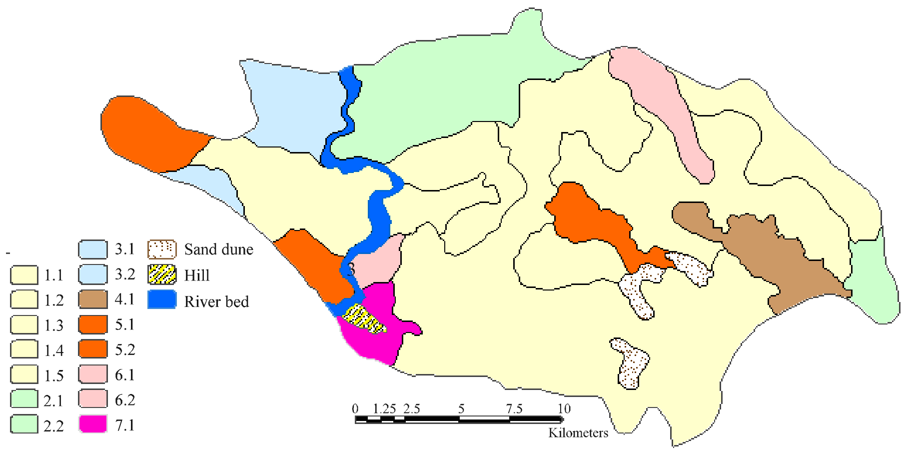

Fig. 1: Soil map of the study area

Table 2: Suitability index (Ci) values and suitability classes of surface, sprinkle and drip irrigation systems for each land units

	Surface irrigation		Sprinkle irrigation		Drip irrigation	
Codes of land units	Ci	Suitability classes	Ci	Suitability classes	Ci	Suitability classes
1.1	29.25	N_{1S}*	50	S_{3S}**	66.5	S_{2S}***
1.2	53.62	S_{3S}	70	S_{2S}	80.75	S_1
1.3	53.62	S_{3S}	70	S_{2S}	80.75	S_1
1.4	53.62	S_{3S}	70	S_{2S}	80.75	S_1
1.5	53.62	S_{3S}	70	S_{2S}	80.75	S_1
2.1	73.12	S_{2S}	90	S_1	90.25	S_1
2.2	49.50	S_{3S}	66.5	S_{2S}	80.75	S_1
3.1	73.12	S_{2S}	90	S_1	90.25	S_1
3.2	85.50	S_1	90.25	S_1	90.25	S_1
4.1	26.32	N_{2S}	45	S_{3S}	56	S_{3S}
5.1	65.81	S_{2S}	81	S_1	76	S_{2S}
5.2	64.12	S_{2S}	81	S_1	76	S_{2S}
6.1	65.81	S_{2S}	81	S_1	76	S_{2S}
6.2	65.81	S_{2S}	81	S_1	76	S_{2S}
7.1	36.85	N_{1NW}	43.87	N_{1SNW}	41.6	N_{1SNW}

*Limiting factors for surface irrigation: s (Soil texture); **Limiting factors for sprinkle irrigation: s (Soil texture); ***Limiting factors for drip irrigation: s (Calcium carbonate and Soil texture)

Seven soil series and fifteen series phases or land units 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 Aridisols and Entisols orders. Also, the soil moisture regime is Aridic while the soil temperature regime is Hyperthermic (KWPA, 2003).

As shown in the Table 2 and 3, for surface irrigation, the land units coded 3.2 (1715 ha, 3.93%) were highly suitable (S_1); land units coded 2.1, 3.1, 5.1, 5.2, 6.1 and 6.2 (5650 ha, 12.93%) were classified as moderately suitable (S_2) and land units coded 1.2, 1.3, 1.4, 1.5 and 2.2 (25320 ha, 57.94%) were found to be marginally suitable (S_3). Also, land units coded 1.1 and 7.1 (7665 ha, 17.54%) were classified as currently not-suitable (N_1). Only land unit coded 4.1 (1670 ha, 3.82%) was classified as permanently not-suitable (N_2) for any surface irrigation exercises.

By analyzing the suitability irrigation maps for surface irrigation (Fig. 2), it is evident that the highly suitability area can be observed just in one land unit (3.2) of the Fakkeh Plain due to deep soil, good drainage, texture and proper slope of the area. The moderately suitable area is located only in some part of this area due to sandy loam soil texture. The others factor such as drainage, depth, salinity and slope never influence the suitability of the area. As seen from the map, the largest part of cultivated area in this plain was evaluated as marginally suitable because of the loamy sand soil texture. The currently not-suitable lands and permanently not-suitable lands can be observed only in the center and east of the plain because of the physical limitations such as sandy soil texture. For almost the entire study area slope, soil depth, salinity, drainage and $CaCO_3$ were never taken as limiting factors.

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

	Surface irrigation			Sprinkle irrigation			Drip irrigation		
Suitability class	Unit code	Area (ha)	Ratio (%)	Unit code	Area (ha)	Ratio (%)	Unit code	Area (ha)	Ratio (%)
S_1	3.2	1715	3.93	2.1, 3.1, 3.2, 5.1, 5.2, 6.1, 6.2	7365	16.86	1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2	28190	64.51
S_2	2.1, 3.1, 5.1, 5.2, 6.1, 6.2	5650	12.93	1.2, 1.3, 1.4, 1.5, 2.2	25320	57.94	1.1, 5.1, 5.2, 6.1, 6.2	11425	26.15
S_3	1.2, 1.3, 1.4, 1.5, 2.2	25320	57.94	1.1, 4.1	8600	19.68	4.1	1670	3.82
N_1	1.1, 7.1	7665	17.54	7.1	735	1.68	7.1	735	1.68
N_2	4.1	1670	3.82	-----	-----	-----	-----	-----	-----
Miscellaneous Lands*		1680	3.84		1680	3.84		1680	3.84
Total		43700	100		43700	100		43700	100

*Miscellaneous Lands: (Hill, Sand Dune and River Bed)

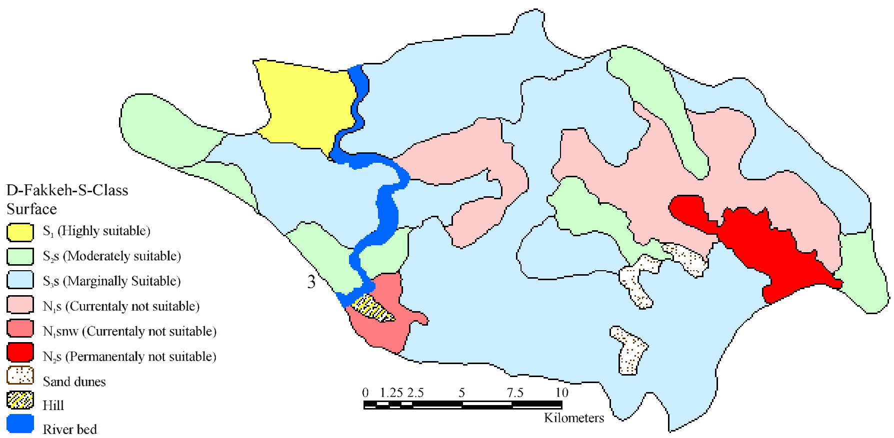

Fig. 2: Land suitability map for surface irrigation

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

For sprinkle irrigation, land units coded 2.1, 3.1, 3.2, 5.1, 5.2, 6.1 and 6.2 (7365 ha, 16.86%) were highly suitable (S_1) while land units coded 1.2, 1.3, 1.4, 1.5 and 2.2 (25320 ha-57.94%) were classified as moderately suitable (S_2). Further, land units coded 1.1 and 4.1 (8600 ha, 19.68%) were found to be slightly suitable (S_3). Only land unit coded 7.1 (735 ha, 1.68%) was classified as currently not-suitable (N_1) for sprinkle irrigation.

In this case (Fig. 3), the highly suitability area can be observed just in some part (west and east) of the Fakke Plain due to proper slope, deep soil, good texture and drainage of the area. As seen from Fig. 3, the largest part of cultivated area in this plain was evaluated as moderately suitable for sprinkle irrigation because of the loamy sand soil texture. The others factor such as drainage, depth, salinity and slope never influence the suitability of the area. The marginally suitable area is located only in two land units coded 1.1 and 4.1 located in east and center of this plain due to sandy soil texture. The currently not-suitable lands can be observed only in one land unit coded 7.1 located in the southwest of the plain because of the salinity and drainage limitation. The permanently not-suitable land 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, land units coded 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1 and 3.2 (28190 ha, 64.51%) were highly suitable (S_1) while land units coded 1.1, 5.1, 5.2, 6.1 and 6.2 (11425 ha, 26.15%) were classified as moderately suitable (S_2). Further, the land unit coded 4.1 (1670 ha, 3.82%) were found to be slightly suitable (S_3). Only land unit coded 7.1 (735 ha, 1.68%) was classified as currently not-suitable (N_1) for drip irrigation.

In this case, (Fig. 4) the highly suitable lands covered nearly a big portion of the plain (64.51%). The slope, soil texture, soil depth, calcium carbonate, salinity and drainage were in good conditions. The moderately

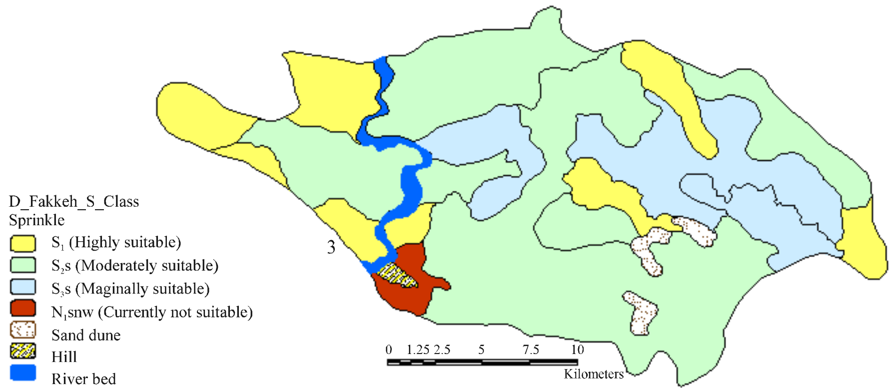

Fig. 3: Land suitability map for sprinkle irrigation

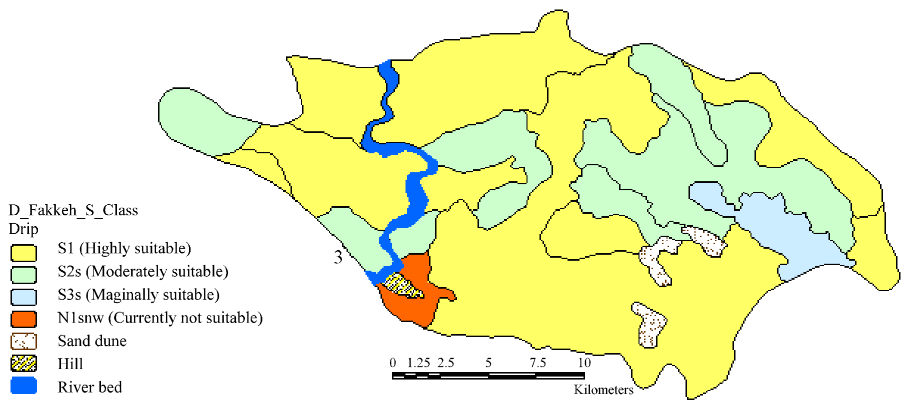

Fig. 4: Land suitability map for drip irrigation

suitable lands could be observed in some part of the plain (east, center and wet parts) due to medium content of calcium carbonate. The marginally suitable lands were founded only in one land unit coded 4.1 located in the east of the area. The limiting factors for this land unit were sandy soil texture and medium content of calcium carbonate. Finally, only a land unit coded 7.1 was classified currently not-suitable for drip irrigation systems in southeast of the plain because of salinity and drainage limitations and also medium content of calcium carbonate. For the entire study area, slope, soil texture, soil depth, drainage and salinity were never considered as limiting factors.

The mean capability index (Ci) for surface irrigation was 56.65 (slightly suitable) while for sprinkle irrigation was 71.97 (moderately suitable). Also, for drip irrigation it was 76.17 (moderately suitable). For the comparison of the capability indices for surface, sprinkle and drip irrigation. Table 2 and 4 indicated that in land units coded 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1 and 4.1 applying drip irrigation systems was the most suitable than surface and sprinkle irrigation systems. In land units coded 5.1, 5.2, 6.1, 6.2 and 7.1 applying sprinkle irrigation systems was the most suitable compared with surface and drip irrigation systems. Only in the land unit coded 3.2 applying drip or sprinkle irrigation systems were the most suitable than surface irrigation systems. Figure 5 shows the most suitable map for surface, sprinkle and drip irrigation systems in the Fakkeh plain by notation to capability index (Ci) for different irrigation systems. As seen from this map, the largest part of this plain was suitable for drip irrigation systems and some part of this area was suitable for sprinkle irrigation systems, also, there was not founded area that was suitable for surface irrigation systems.

The results of Table 4 indicate that by applying drip irrigation instead of surface and sprinkle irrigation methods, suitability classes of land units coded 1.2, 1.3, 1.4, 1.5, 2.1, 2.2 and 3.1 (26475 ha, 60.58%) improved to highly suitable (S_1) and land unit coded 1.1 (6930 ha, 15.87%) was developed to moderately suitable (S_2). In addition, the land unit coded 4.1 (1670 ha, 3.82%) improved to marginally suitable (S_3). The results demonstrate that by applying sprinkle Irrigation instead

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
1.1	66.50	S_{2S}	Drip	Soil texture
1.2	80.75	S_1	Drip	No Exist
1.3	80.75	S_1	Drip	No Exist
1.4	80.75	S_1	Drip	No Exist
1.5	80.75	S_1	Drip	No Exist
2.1	90.25	S_1	Drip	No Exist
2.2	80.75	S_1	Drip	No Exist
3.1	90.25	S_1	Drip	No Exist
3.2	90.25	S_1	Drip/Sprinkle	No Exist
4.1	56.00	S_{3S}	Drip	Soil texture
5.1	81.00	S_1	Sprinkle	No Exist
5.2	81.00	S_1	Sprinkle	No Exist
6.1	81.00	S_1	Sprinkle	No Exist
6.2	81.00	S_1	Sprinkle	No Exist
7.1	43.87	N_{1SNW}	Sprinkle	$CaCO_3$, Salinity and drainage

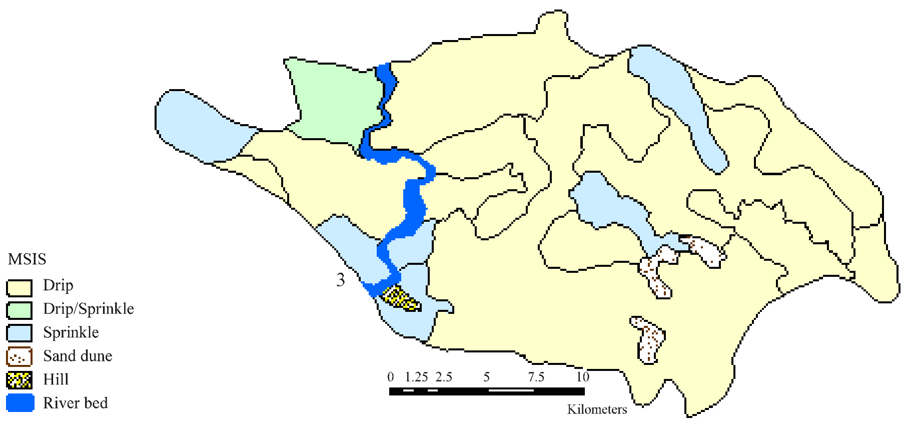

Fig. 5: The most suitable map for different irrigation systems

of surface and drip irrigation methods, suitability classes of land units coded 5.1, 5.2, 6.1 and 6.2 (4495 ha, 10.29%) developed to highly suitable (S_1) and land unit coded 7.1 (735 ha, 1.68%) was developed to currently not-suitable (N_1). Also, for the land unit coded 3.2 (1715 ha, 3.92%) applying drip or sprinkle irrigation systems were improved to highly suitable (S_1). The results demonstrate that by applying drip Irrigation instead of surface and sprinkle irrigation methods, suitability classes of 36790 ha (84.19%) of Fakkeh Plain's land will improved. Also by applying sprinkle Irrigation instead of surface and drip irrigation methods, suitability classes of 6945 ha (15.89%) of this Plain's land will improved The comparison of the different types of irrigation revealed that the drip irrigation was more effective and efficient then the surface and sprinkle irrigation methods improved the suitability to the irrigation purposes. After that, the sprinkle irrigation was more useful than surface irrigation method. Therefore, The most suitable irrigation systems in Fakkeh Plain's land were drip irrigation and sprinkle irrigation respectively. There were not highly suitable lands for surface irrigation system in the studied area (instead of land unit coded 3.2). So that, the surface irrigation system was not suitable for Fakkeh Plain's land. Moreover, the main limiting factor in using surface and sprinkle irrigation methods in this area was soil texture and the main limiting factor in using drip irrigation methods was soil calcium carbonate content.

CONCLUSION

Details are given for the analysis of the field data to compare the suitability of different irrigation systems. The analyzed parameters included soil and land characteristics. The results obtained showed that drip irrigation is more suitable than sprinkle and surface irrigation methods for most of the study area. The major limiting factor for the drip irrigation methods was soil calcium carbonate content, however for sprinkle and surface irrigation methods soil texture was the restricted factor. As seen in the results of the comparison between the maps, introduction of a different irrigation management policy could be an important improvement.

The highly suitable area is very wider for drip irrigation and it includes a large part of the Fakkeh Plain. The drip irrigation can obviously be a way to improve the practice on light soil textures. Of course in the application of this sort of irrigation, an agricultural management change would be necessary: horticulture and mulched crops should replace extensive crops such as wheat, barley, etc actually adopted. This is the same strategy adopted by large companies currently practicing in the area and that can ensure the highest incomes to the farmers.

Such a management change 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 insufficiency of water in arid and semi arid climate, maximizing water use efficiency is necessary to produce more crops per drop and to help for solving the water shortage crisis in the agricultural sector. The shift from surface irrigation to high-tech irrigation technologies, e.g. drip and sprinkle irrigation systems, therefore, offers significant water-saving potentials. Finally, since drip irrigation system typically applies small amount of water on a frequent basis to maintain soil water near field capacity, it would be more beneficial to use drip irrigation method in this plain.

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