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Land Suitability Evaluation for Surface and Drip Irrigation in Shavoor Plain Iran

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Abstract: The main objective of this research is to compare two different irrigation methods according to parametric evaluation system in an area of 77706 ha in Shavoor Region in Khuzestan province, Southwest of 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 Shavoor plain in a scale of 1/20000. After analyzing and evaluating soil properties by means of Geographic Information System (GIS), suitability maps were generated for both methods. The results showed that 14952.07 ha of the studied area were highly suitable for drip Irrigation method though not suitable enough for the surface irrigation method. Also, it was found that some series coded 3, 6, 7, 10, 11, 12, 22 and 23 covering an area of 27578.26 ha were not suitable to be used under both irrigation systems. Ultimately, drip irrigation system was suggested as the best method to be applied to the said study area. The main limiting factors in using both surface and drip irrigation methods in this area were soil salinity and drainage.

Key words: Surface irrigation, drip irrigation, land suitability, parametric method

INTRODUCTION

Global food security and stability deeply depends on the management of the natural resources. Today, some 40% of all world food is obtained from irrigated farmlands. Food production via irrigated agriculture, however, does not correspond to the current rapid population growth. Soil salinity and contamination in addition to the excessive urban development are also the main factors that affect the state of food production by irrigated agriculture (Conway, 2003).

The available water resources may not be able to meet various demands 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 of a defined use. According to the FAO (1976), methodology this is strongly related to the land qualities including erosion resistance, water availability and flood hazard that are not measurable. As these qualities derive from the land characteristics, such as slope angle and length, rainfall and soil texture which are measurable or estimable, it is advantageous to use these 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 the 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

Hired *et al.* (1996) and Bond (2002) improved the classification methods for evaluating suitability for effluent irrigation and land suitability for irrigation. These factors influence the land suitability in an irrigation practice included soil properties and topography. Tesfai (2002) investigated a land suitability method for gravity (surface) irrigation schemes in the Sheeb area of Eritrea. According to the results, in surface irrigation practice, 16% of the study area was highly to moderately suitable (S_1 and S_2), 24% was classified as moderately suitable (S_2), 17% was marginally suitable (S_3) and 40% of the area was decided as unsuitable (N_1) for surface irrigation. The main limiting factor for surface irrigation was soil salinity, 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. Under surface

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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 and 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, bad 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 worked out in the surface irrigation suitability evaluation. Rees and Laffan (2004) studied the land suitability for spray irrigation in the Southwood Processing Complex, southern Tasmania. In this research, soil properties such as depth, texture, structure, hydraulic conductivity, massive hardpan, stone content and topographic properties such as slop, land form, surface rock, frequent waterlogging and drainage properties were considered as to be the main factors in land suitability evaluation for any spray irrigation practice.

Barberis and Minelli (2005) provided land suitability classification for both surface and drip irrigation methods in Shouyang country, Shanxi province, China. 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 one (62%). The most limiting factors were physical parameters including slope and soil depth.

Intensive application of water alters water distribution in the surroundings and affects the transfer rate of the pollutants in the soil, soil density, erosion, salinity, alkalinity, waterlogging, etc. Water and soil compatibility in any irrigation practice is of outmost importance and should it be no so, irrigation water will bring about adverse impacts on the physico-chemical properties of the soil in long run. To determine the main objective of this study is to evaluate and compare land suitability for surface and drip irrigation methods according to the parametric evaluation for Shavoor Plain. To determine such compatibility, detailed evaluation of soil properties and topography is required.

MATERIALS AND METHODS

The present study was conducted in an area about 77706 hectares in Shavoor Plain in Khuzestan province, southwest of Iran in year of 2006. The study area is located 40 km north Ahwaz between 31° 37′, 32° 30′ N and 48°15′, 48°40′ E. Average annual temperature and precipitation for the period of 1966-2004 were 25.3°C and 260 mm, respectively. The annual evaporation is over 2000 mm (KWPA, 2005).

The main water resource to this area is Shavoor 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 three distinct physiographic features i.e., plateau river, alluvial plain and low land, particularly river alluvial plain physiographic units are common. Twenty five different soil series were found in the area. To determine soil a characteristic, the semi-detailed soil survey report of Shavoor was used (KWPA, 2006). The land evaluation was determined based upon topography and soil characteristics. The topography characteristics included slope while soil properties included soil texture, depth, salinity, drainage and carbonate content. Also, soil properties such as Cation Exchange Capacity (CEC), Percentage of Basic Saturation (PBS), 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.

Based upon the profile description and laboratory analysis, that group of soils that had similar properties and located in a same physiographic unit were considered as a series of soils and were taxonomies to form a soil family as per to keys to soil taxonomy 2006. Ultimately, 25 soil series were selected for the surface and drip irrigation land suitability.

For determination the average of 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 2, 1.5, 1, 0.75, 0.5 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.

Table 1: Suitability classes for the irrigation capability indices (Ci) classes

Symbols	Definition	Capability index
S_1	Highly suitable	>80
S_2	Moderately suitable	60-80
S_3	Marginally suitable	45-59
N_1	Currently not suitable	30-44
N_2	Permanently not suitable	<29

Six parameters were considered which are, slope, drainage properties, electrical conductivity of soil solution, calcium carbonates status, soil texture and Soil depth.

Rates are assigned to the aforementioned six parameters as per the related tables, thus, a capability index for irrigation (Ci) was developed as shown in the equation below:

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

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

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

RESULTS

Twenty-five soil series and sixty-five series phases were derived from the semi-detailed soil study of the area. The soil series are shown in Fig. 1 as the basis for any land evaluation practice. The soils of the area are of Aridisols and Entisols orders. Also, the soil moisture regimes are Aquic and Ustic while the soil temperature regime is Hyperthermic (KWPA, 2006).

As shown in the Table 2, 3 and Fig. 2, 3 for the surface or gravity irrigation, the soil series coded 1, 4, 5, 13, 14, 15, 16, 18, 20 and 21 (31702. 46 ha-40.82%) were classified as moderately suitable (S_2) and soil series coded 2, 8, 9, 18, 19 and 24 (14549. 48 ha-18.72%) were found to be marginally suitable (S_3).

For drip and localized irrigation, soil series coded 2, 4, 5, 14 and 15 (14952.07 ha-19.24%) are highly suitable (S_1) and soil series coded 1, 8, 13, 16, 17, 18, 20, 21 and 25 (22813.78 ha, or 29.36%) were classified as moderately suitable (S_2). Only soil series coded 9, 19 and 24 (8484.09 ha-10. 92%) were found to be slightly suitable (S_3).

Moreover, soil series coded 3, 6, 7, 10, 11, 12, 22 and 23 (27578. 26 ha-35.49%) were classified either currently or permanently as not-suitable (N_1 and N_2) for both surface and drip irrigation exercises.

The results of Table 4 indicate that by applying drip irrigation instead of surface irrigation methods, suitability classes of soil series coded 4, 5, 14 and 15 (11931.44 ha, or 15.35%) improved from moderately suitable (S_2) to highly suitable (S_1) and soil series coded 2 (3020.63 ha or 3.89%) improved from marginally suitable (S_3) to highly suitable (S_1). In addition, soil series coded 8 and 17

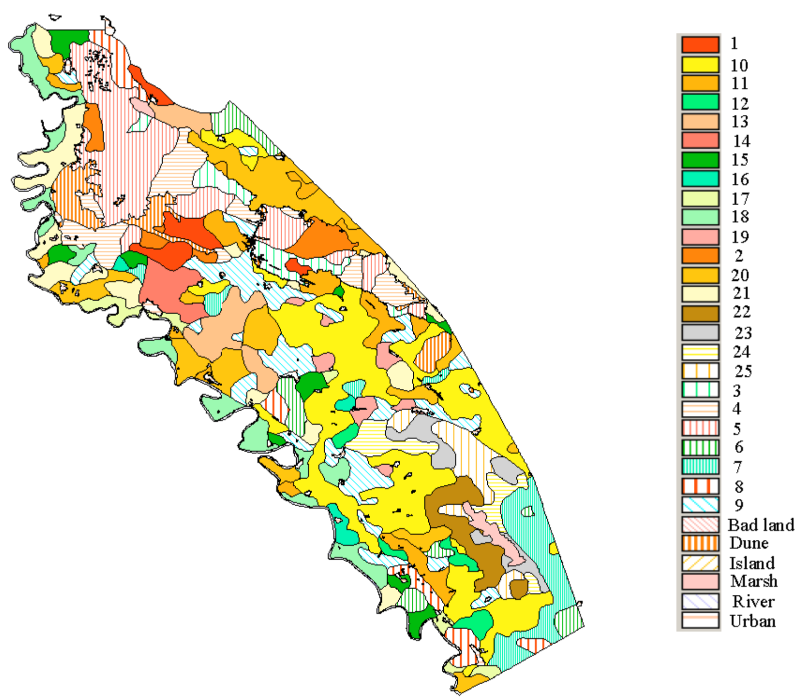

Fig. 1: Soil map of the study area

Table 2: Ci values and suitability classes of gravity and drip irrigation for each soil series

	Gravity irrigation		Drip irrigation	
Codes of series	Ci	Suitability classes	Ci	Suitability classes
1	70.39	S_2	78.49	S_2
2	58.87	S_3	83.31	S_1
3	20.33	N_2	20.33	N_2
4	66.02	S_2	84.60	S_1
5	67.83	S_2	88.34	S_1
6	31.98	N_1	38.13	N_1
7	26.97	N_2	33.90	N_1
8	53.82	S_3	59.05	S_2
9	45.56	S_3	53.17	S_3
10	7.53	N_2	8.99	N_2
11	20.44	N_2	19.41	N_2
12	11.04	N_2	10.56	N_2
13	59.59	S_2	69.39	S_2
14	74.75	S_2	89.03	S_1
15	75.89	S_2	80.24	S_1
16	74.26	S_2	79.02	S_2
17	45.59	S_3	67.56	S_2
18	67.05	S_2	71.50	S_2
19	56.06	S_3	53.50	S_3
20	60.62	S_2	70.79	S_2
21	67.04	S_2	71.49	S_2
22	20.37	N_2	19.25	N_2
23	33.38	N_1	34.37	N_1
24	44.86	S_3	44.58	S_3
25	71.83	S_2	68.03	S_2

Table 3: Distribution of gravity and drip irrigation suitability

	Gravity irrigation			Drip irrigation		
Suitability	Ratio (%)	Area (ha)	Land units	Ratio (%)	Area (ha)	Land units
S_1	-	-	-	19.24	14952.07	2,4,5,14,15
S_2	40.82	31702.46	1,4,5,13,14,15,16, 18,20,21	29.36	22813.78	1,8,13,16,17,18, 20,21,25
S_3	18.72	14549.48	2,8,9,17,19,24	10.92	8486.09	9,19,24
N_1	4.45	3459.14	6,23	8.96	6962.50	6,7,23
N_2	31.04	24119.12	3,7,10,11,12,22	26.53	20615.76	3,10,11,12,22
Miscellaneous land	4.99	3876.06		4.99	3876.06	
Total	100.00	77706.26		100.00	77706.26	

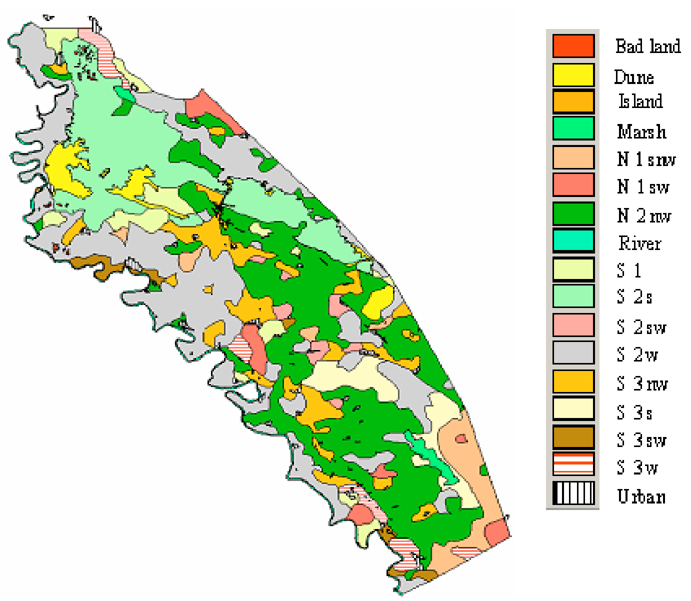

Fig. 2: Land suitability map for surface irrigation

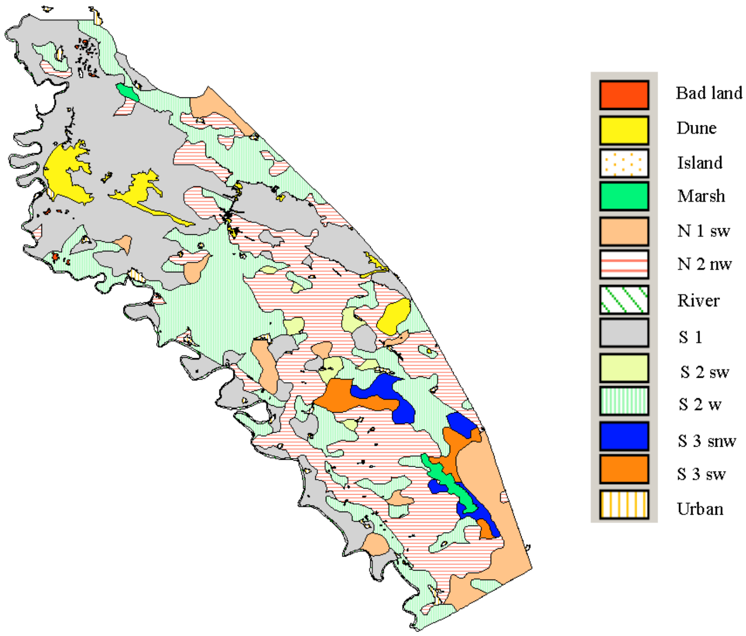

Fig. 3: Land suitability map for drip irrigation

Table 4: Comparison of the land units for both surface and drip irrigation methods

Land units	Improvement of suitability classes from gravity to drip irrigation
4,5,14,15	From S_2 to S_1
2	From S_3 to S_1
8, 12	From S_3 to S_2
7	From N_2 to N_1

(3042.76 ha-3.92%) developed from marginally suitable (S_3) to moderately suitable (S_2) and soil series coded 7 (3503.36 ha-4.51%) developed from permanently not suitable (N_2) to currently not suitable (N_1). The comparison of the two types of irrigation revealed that the drip irrigation was more effective and efficient as the latter mode improves the suitability to the irrigation purposes. Moreover, The main limiting factors in using both surface and drip irrigation methods in this area were soil salinity and drainage. 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 texture and soil depth. Dengiz (2005) 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 with the drip method increased the land suitability by 38% compare to the surface irrigation method.

The most important limiting factors for surface or gravity 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.

CONCLUSIONS

Details are given of the analyzing field data to compare the suitability of two irrigation systems. The analyzing parameters included soil and land characteristics. The results showed that drip irrigation proved more suitable than surface irrigation system in the study area, however, the major limiting factors for the both irrigation methods were soil salinity and drainage. Since drip irrigation system typically applies small amount of water on a frequent basis, maintaining soil water near field capacity, therefore, it would be more benefit to use the drip irrigation method. In arid climates and regions, hence, is recommended to be exercised as the best suitable method for the study area.

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