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# AN INVESTIGATION OF IRRIGATION METHODS BASED ON THE PARAMETRIC EVALUATION APPROACH IN ARAYEZ PLAIN – IRAN

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K e y w o r d s: Surface irrigation, sprinkle irrigation, drip irrigation, parametric method, soil series.

A b s t r a c t

The main objective of this research is to compare different irrigation methods based upon a parametric evaluation system in an area of 54 000 ha in the Arayez plain – Iran. The results demonstrated that by applying sprinkle irrigation instead of surface and drip irrigation methods, the arability of 35 855.73 ha (66.40%) in the Arayez Plain will improve. In addition by applying drip Irrigation instead of surface and sprinkle irrigation methods, the land suitability of 16 644.27 ha (30.82%) of this Plain will improve. The comparison of the different types of irrigation techniques revealed that the sprinkle and drip irrigations methods were more effective and efficient than the surface irrigation methods for improving land productivity. It is of note however that the main limiting factor in using different irrigation methods in this area are soil texture, salinity & alkalinity, drainage, calcium carbonate content and slope.

## OCENA PARAMETRYCZNA SYSTEMÓW NAWADNIANIA NA RÓWNINIE ARAYEZ W IRANIE

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S ł o w a k l u c z o w e: nawadnianie powierzchniowe, nawadnianie deszczownianie, nawadnianie kroplowe, metoda parametryczna, serie glebowe.

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A b s t r a k t

Głównym celem badań było porównanie za pomocą metody parametrycznej różnych systemów nawadniania obszaru o powierzchni 54 tys. ha na równinie Arayez w Iranie. Uzyskane wyniki wykazały, że zastosowanie nawadniania deszczownianego, zamiast powierzchniowego i kroplowego, pozwoli poprawić zdolność produkcyjną gleby na 35 855,73 ha (66,40%) badanego terenu. Zastosowanie nawadniania kroplowego, zamiast powierzchniowego i deszczownianego, zwiększy ponadto przydatność rolniczą 16 644,27 ha (30,82%) gleb analizowanej równiny. Porównanie różnych technik nawadniania wykazało, że nawadnianie deszczowniane i kroplowe, w odniesieniu do produktywności gleby, to systemy efektywniejsze i wydajniejsze niż nawadnianie powierzchniowe. Należy jednak zaznaczyć, że głównymi czynnikami ograniczającymi użycie różnych metod nawadniania na równinie Arayez są: struktura gleby, jej zasolenie i alkaliczność oraz właściwości drenażowe, zawartość węglanu wapnia i spadek terenu.

## 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, 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, 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. (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 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. (2009) compared the different irrigation methods based on the parametric evaluation approach in Abbas Plain: Iran. The results demonstrated that by applying sprinkle irrigation instead of surface and drip irrigation methods, the arability of 21 250 ha (72.53%) in the Abbas Plain will improve. In addition by applying drip irrigation instead of surface and sprinkle irrigation methods, the land suitability of 6275 ha (21.42%) 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 methods for improving land productivity. It is of note, however, that the main limiting factor in using either surface and/or sprinkle irrigation methods in this area is soil texture and the main limiting factor in using drip irrigation methods were soil calcium carbonate content and soil texture.

NASERI et al. (2009) investigated the land suitability for different irrigation systems in Lali Plain, Iran. The results showed that 1732 ha (48.5%) of the studied area was highly suitable for all of the irrigations methods, whereas 384 ha (10.8%) of the study area was unsuitable for surface irrigation methods. Also, for sprinkler and drip irrigation systems the unsuitable lands did not exist in this zone.

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 Arayez Plain, in the Khuzestan Province, Iran.

## Materials and Methods

The present study was conducted in an area about 54 000 hectares in the Arayez Plain, in the Khuzestan Province, located in the Southwest of Iran during 2007–2008. The study area is located 80 km Northwest of the city of Ahwaz, 31° 18' to 32° 30' N and 47° 30' to 47° 55' E. The Average annual temperature and precipitation for the period of 1965–2004 were 25.9°C and 264 mm, respectively. Also, the annual evaporation of the area is 2380 mm (*Khuzestan Water and Power Authority*. 2005). The Karkheh 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 three distinct physiographic features i.e. Piedmont Alluvial Plains, Coalescing Alluvial-Colluvial Fans and Plateaux, of which the Piedmont Alluvial Plains physiographic unit is the dominating features. Also, twenty four different soil series were found in the area. The semi-detailed soil survey report of the Arayez plain (*Khuzestan Water and Power Authority*. 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 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 (2000)[14]. Ultimately, twenty four 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 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:

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

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 | $N_2$ |

In order to develop land suitability maps for different irrigation methods, a semi-detailed soil map (Figure 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.

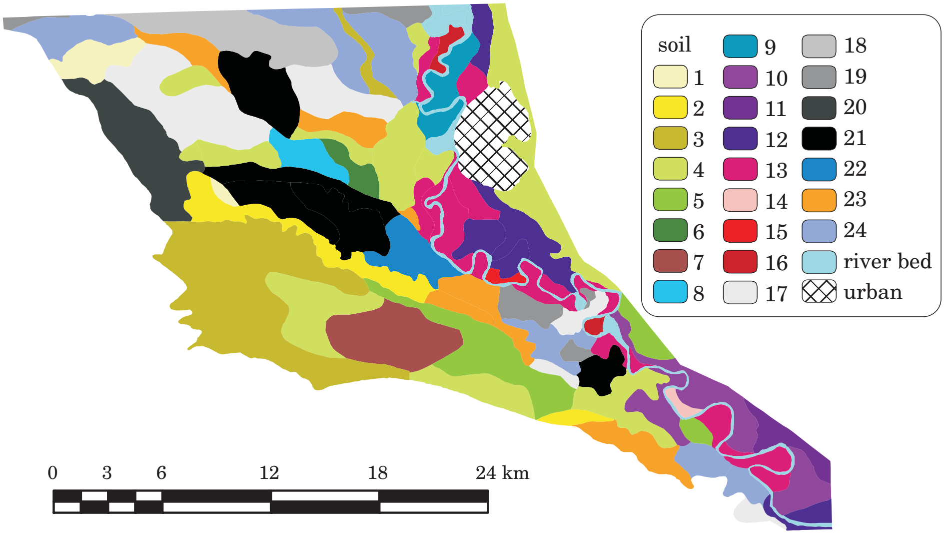


Fig. 1. Soil map of the study area

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 24 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.

## Results

Over much of the Arayez 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 Arayez Plain.

Twenty four soil series or land units and fifty four series phases were derived from the semi-detailed soil study of the area. The land units are shown in Figure 1 as the basis for further land evaluation practice. The soils of the area are of Aridisols, order. Also, the soil moisture regime is Aridic while the soil temperature regime is Hyperthermic (*Khuzestan Water and Power Authority*. 2003).

As shown in Table 2 and Table 3 for surface irrigation, the soil series coded 13, 15, and 20 (5637.81 ha – 10.45%) were highly suitable ($S_1$); soil series coded 2, 6, 9,12 and 16 (7300 ha – 13.47 %) were classified as moderately suitable ($S_2$), and soil series coded 8, 17, 23 and 24 (9150 ha – 16.95%) were found to be marginally suitable ($S_3$). soil series coded 1, 3, 4, 5, 10, 11, 14, 18, 19 and 21 (27 581.46 ha – 51.11%) were classified as currently not-suitable ($N_1$).Also, soil series coded 7 and 22 (9150 ha – 16.95%) were found to be permanently not-suitable ($N_2$) for any surface irrigation practices.

Table 2

*Ci* values and suitability classes of surface, sprinkle and drip irrigation for each land units

| Codes of land units | Surface irrigation | | Sprinkle irrigation | | Drip irrigation | |
|---|---|---|---|---|---|---|
| | *Ci* | suitability classes | *Ci* | suitability classes | *Ci* | suitability classes |
| 1 | 38.47 | $N_{1S}$* | 51.33 | $S_{3S}$** | 53.20 | $S_{3S}$*** |
| 2 | 73.10 | $S_{2T}$ | 77.16 | $S_{2S}$ | 72.20 | $S_{2S}$ |
| 3 | 43.87 | $N_{1N}$ | 45.00 | $S_{3N}$ | 40.00 | $N_{1SN}$ |
| 4 | 40.28 | $N_{1SW}$ | 47.24 | $S_{3SW}$ | 45.22 | $S_{3SW}$ |
| 5 | 35.80 | $N_{1SNW}$ | 42.27 | $N_{1SNW}$ | 40.46 | $N_{1SNW}$ |
| 6 | 67.13 | $S_{2S}$ | 72.67 | $S_{2S}$ | 64.60 | $S_{2S}$ |
| 7 | 23.87 | $N_{2SNW}$ | 29.26 | $N_{1SNW}$ | 28.90 | $N_{2SNW}$ |
| 8 | 52.21 | $S_{3SN}$ | 57.37 | $S_{3SN}$ | 51.00 | $S_{3SN}$ |
| 9 | 67.52 | $S_{2S}$ | 73.10 | $S_{2S}$ | 68.40 | $S_{2S}$ |
| 10 | 35.54 | $N_{1N}$ | 38.47 | $N_{1N}$ | 36.00 | $N_{1SN}$ |
| 11 | 41.77 | $N_{1SNW}$ | 51.64 | $S_{3SN}$ | 51.00 | $S_{3SN}$ |
| 12 | 63.18 | $S_{2W}$ | 76.95 | $S_{2S}$ | 76.00 | $S_{2S}$ |
| 13 | 87.75 | $S_1$ | 90.00 | $S_1$ | 80.00 | $S_1$ |
| 14 | 43.87 | $N_{1N}$ | 45.00 | $S_{3N}$ | 40.00 | $N_{1SN}$ |
| 15 | 87.75 | $S_1$ | 90.00 | $S_1$ | 80.00 | $S_1$ |
| 16 | 65.81 | $S_{2S}$ | 81.00 | $S_1$ | 76.00 | $S_{2S}$ |
| 17 | 48.26 | $S_{3S}$ | 63.00 | $S_{2S}$ | 68.00 | $S_{2S}$ |
| 18 | 39.60 | $N_{1TS}$ | 53.55 | $S_{3TS}$ | 61.20 | $S_{2S}$ |
| 19 | 39.60 | $N_{1TS}$ | 53.55 | $S_{3TS}$ | 61.20 | $S_{2S}$ |
| 20 | 81.22 | $S_1$ | 83.36 | $S_1$ | 76.00 | $S_{2S}$ |
| 21 | 36.45 | $N_{1S}$ | 50.01 | $S_{3S}$ | 53.20 | $S_{3S}$ |
| 22 | 16.20 | $N_{2TS}$ | 20.65 | $N_{2TS}$ | 20.52 | $N_{2S}$ |
| 23 | 44.55 | $S_{3S}$ | 59.85 | $S_{2S}$ | 68.00 | $S_{2S}$ |
| 24 | 47.02 | $S_{3S}$ | 61.42 | $S_{2S}$ | 68.00 | $S_{2S}$ |

*, ** – limiting factors for surface and sprinkle irrigations: S (soil texture), N (salinity & alkalinity), W (drainage) & T (slope).
*** – limiting factors for drip irrigation: S (Calcium Carbonate, soil texture), N (salinity & alkalinity), W (drainage) & T (Slope).

The analysis of the suitability irrigation maps for surface irrigation (Figure 2), indicate that the some part of the cultivated area in this plain (located in the west and east) are deemed as being highly suitable land due to deep soil, good drainage, texture, salinity and proper slope of the area.

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 (%) |
| $S_1$ | 13, 15, 20 | 5 637.81 | 10.45 | 13, 15, 16, 20 | 6 812.81 | 12.62 | 13, 15 | 3475 | 6.45 |
| $S_2$ | 2, 6, 9, 12, 16 | 7300 | 13.47 | 2, 6, 9, 12, 17, 23, 24 | 14 725 | 27.23 | 2, 6, 9, 12, 16, 17, 18, 19, 20, 23, 24 | 21 237.81 | 39.29 |
| $S_3$ | 8, 17, 23, 24 | 9150 | 16.95 | 1, 3, 4, 8, 11, 14, 18, 19, 21 | 24 706.53 | 45.78 | 1, 4, 8, 11, 21 | 12 944.27 | 23.97 |
| $N_1$ | 1, 3, 4, 5, 10, 11, 14, 18, 19, 21 | 27 581.46 | 51.11 | 5, 7, 10 | 5350 | 9.91 | 3, 5, 10, 14 | 12 012.19 | 22.27 |
| $N_2$ | 7, 22 | 28 30.73 | 5.24 | 22 | 905.73 | 1.68 | 7, 22 | 2 830.73 | 5.24 |
| *Mis Land | | 1500 | 2.78 | | 1500 | 2.78 | | 1500 | 2.78 |
| Total | | 54 000 | 100 | | 54 000 | 100 | | 54 000 | 100 |

* Miscellaneous Land: (hill, sand dune and river bed)

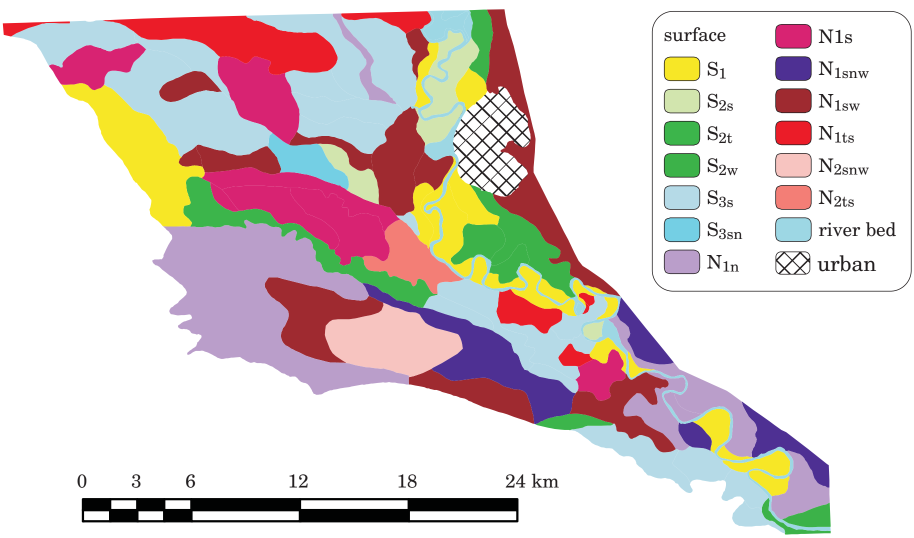


Fig. 2. Land suitability map for surface irrigation: $S_1$ – highly suitable, $S_{2s}$ – moderately suitable, $S_{2t}$ – moderately suitable, $S_{2w}$ – moderately suitable, $S_{3s}$ – marginally suitable, $S_{3sn}$ – marginally suitable, $N_{1n}$ – currently not suitable, $N_{1s}$ – currently not suitable, $N_{1snw}$ – currently not suitable, $N_{1sw}$ – currently not suitable, $N_{2snw}$ – currently not suitable, $N_{2ts}$ – permanently not suitable

The moderately suitable area is located to the center and east of this area due to sandy loam soil texture. Other factors such as drainage, depth, salinity and alkalinity have no influence on the suitability of the area what soever. The map also indicates that some portions of the cultivated area in this plain was evaluated as marginally suitable because of the loamy sand soil texture and gently slope. The current non-suitable land can be observed in the largest portion of the plain because of sever salinity, alkalinity and drainage limitations. The permanently non-suitable land covered the smallest part of this plain, due to very sever salinity, alkalinity and drainage limitations. For almost the total study area elements such as soil depth 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 (Table 2 and Table 3).

For sprinkle irrigation, soil series coded 13, 15, 16 and 20 (6812.81 ha – 12.62%) were highly suitable ($S_1$) while soil series coded 2, 6, 9, 12, 17, 23 and 24 (14725 ha – 27.23%) were classified as moderately suitable ($S_2$). Also, soil series coded 1, 3, 4, 8, 11, 14, 18, 19 and 21 (24 706.53 ha – 45.78%) were marginal suitable ($S_3$). soil series coded 5, 7 and 10 (5350 ha – 9.91%) were found to be currently non-suitable ($N_1$). Further, only soil series coded 22 (2150 905.73 ha – 1.68%) was classified as permanently not-suitable ($N_2$) for sprinkle irrigation.

Regarding sprinkler irrigation, (Figure 3) the highly suitable area can be observed in the some part of the cultivated zone in this plain (located in the west and the east) due to deep soil, good drainage, texture, salinity and proper slope of the area. As seen from the map, some 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 influence the suitability of the area. The map also indicates that the largest parts (45.78%) of the cultivated area in this zone was evaluated as marginally suitable because of the sandy soil texture and gently slope. The current non-suitable lands are located only in the south and southwest of the plain and their non-suitability of the land is due to the sever salinity, alkalinity and drainage limitations. The permanently not-suitable lands just exist in the smallest part of this area because of very sever salinity, alkalinity and drainage limitations For almost the entire study area soil depth and $CaCO_3$ were never taken as limiting factors.

For drip irrigation, soil series coded 13 and 15 (3475 ha – 6.45%) were highly suitable ($S_1$) while soil series coded 2, 6, 9, 12, 16, 17, 18, 19, 20, 23 and 24 (21 237.81 ha – 39.29%) were classified as moderately suitable ($S_2$). Further, soil series coded 1, 4, 8, 11 and 21 (12 944.27 ha – 23.97%) were found to be

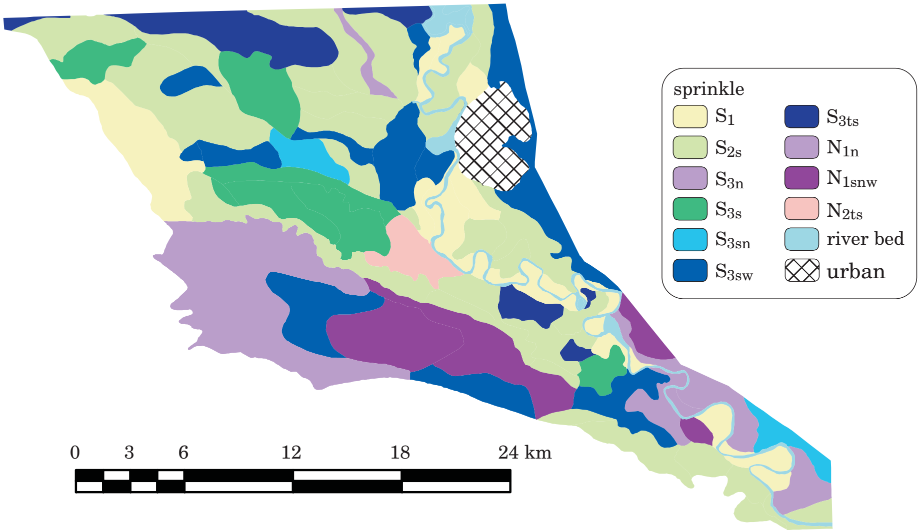


Fig. 3. Land suitability map for sprinkle irrigation: $S_1$ – highly suitable, $S_{2s}$ – moderately suitable, $S_{3n}$ – marginally suitable, $S_{3s}$ – marginally suitable, $S_{3sn}$ – marginally suitable, $S_{3sw}$ – marginally suitable, $S_{3ts}$ – marginally suitable, $N_{1n}$ – currently not suitable, $N_{1snw}$ – currently not suitable, $N_{2ts}$ – permanently not suitable

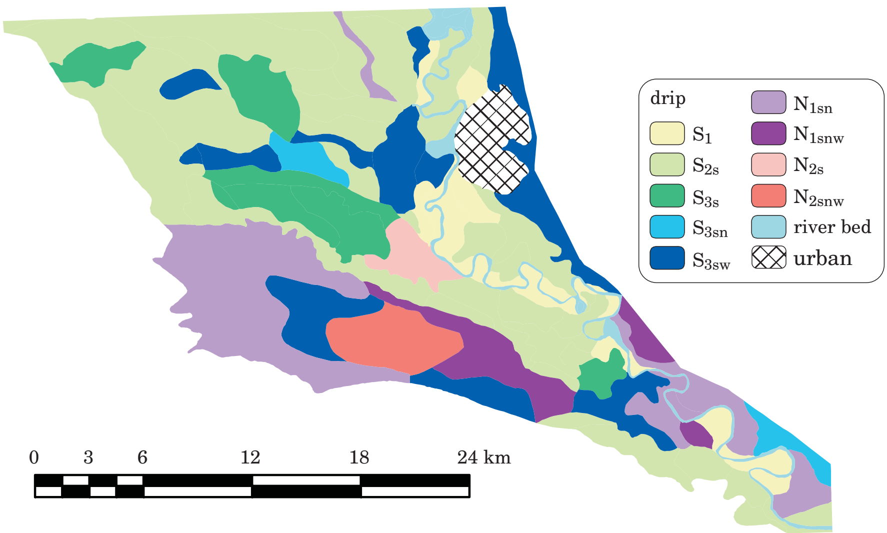


Fig. 4. Land suitability map for drip irrigation: $S_1$ – highly suitable, $S_{2s}$ – moderately suitable, $S_{3s}$ – marginally suitable, $S_{3sn}$ – marginally suitable, $S_{3sw}$ – marginally suitable, $N_{1sn}$ – currently not suitable, $N_{1snw}$ – currently not suitable, $N_{2s}$ – permanently not suitable, $N_{2snw}$ – permanently not suitable

slightly suitable ($S_3$). Soil series coded 3, 5, 10 and 14 (12012.19 ha – 22.27%) were classified as currently non-suitable ($N_1$). Also, soil series coded 7 and 22 (2830.73 ha – 5.24%) were permanently not-suitable ($N_2$) for any drip irrigation systems.

Regarding drip irrigation (Figure 4), the highly suitable lands covered the small 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 (north, center and south parts) due to the medium content of calcium carbonate and loamy sand soil texture. The marginally suitable lands were found in the some part of the area.The limiting factors for this land unit was the medium content of calcium carbonate. Current non-suitable lands and permanently non-suitable land exist in the southwest and south of this area because of very sever salinity,

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 | 53.2 | $S_{3S}$ | drip | S |
| 2 | 77.16 | $S_{2S}$ | sprinkle | S |
| 3 | 45 | $S_{3N}$ | sprinkle | N |
| 4 | 47.24 | $S_{3SW}$ | sprinkle | SW |
| 5 | 42.27 | $N_{1SNW}$ | sprinkle | SNW |
| 6 | 72.67 | $S_{2S}$ | sprinkle | S |
| 7 | 29.26 | $N_{1SNW}$ | sprinkle | SNW |
| 8 | 57.37 | $S_{3SN}$ | sprinkle | SN |
| 9 | 73.10 | $S_{2S}$ | sprinkle | S |
| 10 | 38.47 | $N_{1N}$ | sprinkle | N |
| 11 | 51.64 | $S_{3SN}$ | sprinkle | SN |
| 12 | 76.95 | $S_{2S}$ | sprinkle | S |
| 13 | 90 | $S_1$ | sprinkle | no exist |
| 14 | 45 | $S_{3N}$ | sprinkle | N |
| 15 | 90 | $S_1$ | sprinkle | no exist |
| 16 | 81 | $S_1$ | sprinkle | no exist |
| 17 | 68 | $S_{2S}$ | drip | S |
| 18 | 61.2 | $S_{2S}$ | drip | S |
| 19 | 61.2 | $S_{2S}$ | drip | S |
| 20 | 83.36 | $S_1$ | sprinkle | no exist |
| 21 | 53.2 | $S_{3S}$ | drip | S |
| 22 | 20.65 | $N_{2TS}$ | sprinkle | S |
| 23 | 68 | $S_{2S}$ | drip | S |
| 24 | 68 | $S_{2S}$ | drip | S |

* limiting factors for sprinkle irrigations: S (soil texture), N (salinity & alkalinity), W (drainage) & T (slope).

Limiting factors for drip irrigation: S (Calcium Carbonate, soil texture), N (salinity & Alkalinity), W (drainage) & T (slope).

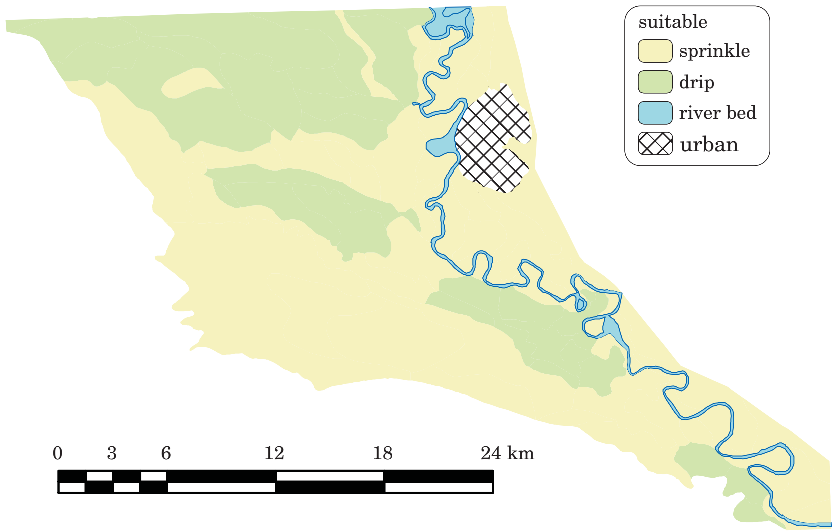


Fig. 5. The most suitable map for different irrigation systems

alkalinity and drainage limitations. For the entire study area only soil depth, was never considered as limiting factors.

For the comparison of the capability indices for surface, sprinkle and drip irrigation, Table 2 and Table 4 indicated that in soil series coded 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 20 and 22 applying sprinkle irrigation systems was more suitable than drip and surface irrigation systems. In soil series coded 1, 17, 18, 19, 21, 23 and 24 applying drip irrigation systems was the most suitable option as compared to sprinkle and surface irrigation systems. Figure 5 shows the most suitable map for surface, sprinkle and drip irrigation systems in the Arayez 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 Table 2 and Table 4 indicated that by applying sprinkle irrigation instead of drip and surface irrigation methods, the land suitability of 35 855.73 ha (66.40%) of the Arayez Plain's land could be improved substantially. However by applying drip Irrigation instead of surface and sprinkle irrigation methods, the suitability of 16 644.27 ha (30.82%) 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 plain. 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 Arayez Plain' were sprinkle irrigation, drip irrigation and surface irrigation respectively. Moreover, the main limiting factors in using sprinkle and surface irrigation methods in this area were soil texture, salinity & alkalinity, drainage and slope, and the main limiting factors in using drip irrigation methods were the soil's calcium carbonate content, soil texture, salinity & alkalinity, drainage and slope.

## Discussion

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 factors for both sprinkle and surface irrigation methods were soil texture, salinity & alkalinity, drainage and slope, however for drip irrigation method, soil's calcium carbonate content, soil texture, salinity & alkalinity, drainage and slope, 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.

## Conclusions

The surface irrigation system, characterized by excessive water use, is currently applied in the Arayez Plain. Water deficiency in arid and semi-arid climate zones is a serious concern, and the irrigation systems used in such areas should be efficient and optimized so as to reduce the amount of water used. The objective of the study was to select the most suitable irrigation method for the Arayez Plain, Iran, where agricultural irrigation systems are commonly applied. Surface, sprinkle and drip irrigation techniques were compared using a parametric evaluation system, based on an analysis of soil properties. The results of this study showed that sprinkle and drip irrigation systems are more suitable for the majority of soils in the Arayez Plain than the surface irrigation technique; 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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## References

ALBAJI M., LANDI A., BOROOMAND NASAB S., MORAVEJ K. 2008. *Land suitability evaluation for surface and drip irrigation in Shavoor Plain Iran*. Journal of Applied Sciences, 8(4): 654–659.

ALBAJI M., BOROOMAND NASAB S., NASERI A.A., JAFARI S. 2009. *Comparison of different irrigation methods based on the parametric evaluation approach in Abbas Plain: Iran*. Journal of Irrigation and Drainage Engineering© ASCE (under publishing).

BARBERIS A., MINELLI S. 2005. *Land evaluation in the Shouyang Country, Shanxi Province, China*. 25th Course Professional Master. 8th Nov 2004–23 Jun 2005. IAO, Florence, Italy, http://www.iao.florence.it/training/geomatics/Shouyang/China_25hq.pdf.

BAZZANI F., INCERTI F. 2002. *Land evaluation in the Province of Larache, Morocco*. 22nd Course Professional Master. Geometric and Natural Resources Evaluation. 12 Nov 2001–21 June 2002. IAO, Florence, Italy, http://www.iao.florence.it/training/geomatics/Larache/Morocco_22.pdf.

BIENVENUE J.S., NGARDETA M., MAMADOU K. 2003. *Land evaluation in the province of Thies, Senegal*. 23rd Course Professional Master. Geometric and Natural Resources Evaluation. 8th Nov 2002–20 June 2003. IAO, Florence, Italy. http://www.iao.florence.it/training/geomatics/Thies/senegal23.pdf.

Briza Y., Dileonardo F., Spisni A. 2001. *Land evaluation in the province of Ben Slimane, Morocco*. 21st Course Professional Master.Remote Sensing and Natural Resource Evaluation. 10 Nov 2000–22 June 2001. IAO, Florence, Italy, http://www.iao.florence.it/training/geomatics/BenSlimane/Marocco21.pdf.

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.

Food and Agriculture Organization of the United Nations (FAO). 1976. *A framework for land evaluation*. Soil Bulletin, 32: 72 pp., FAO, Rome, Italy, http://www.fao.org/docrep/x5310e/x5310e00.htm.

Hargreaves H.G., 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). 2005. *Meteorology Report of Arayez Plain, Iran* (in Persian), http://www.kwpa.com.

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

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

Mbodj C., Mahjoub I., Sghaiev N. 2004. *Land evaluation in the Oud Rmel Catchment, Tunisia*. 24th Course Professional Master. Geometric and Natural Resources Evaluation. 10th Nov 2003–23 rd Jun 2004. IAO, Florence, Italy. http://www.iao.florence.it/training/geomatics/Zaghouan/Tunisia–24lq.pdf.

Naseri A.A., Rezania A.R., Albaji M. 2009. *Investigation of soil quality for different irrigation systems in Lali Plain, Iran*. Journal of Food, Agriculture & Environment, 7(3&4): 955–960.

Sys C., van Ranst E., Debaveye J. 1991. *Land evaluation*. I. *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.