LAND EVALUATION FOR SUSTAINABLE PRODUCTIVITY IN THE SOUTHERN TOHAMA PLAINS, SAUDI ARABIA

By

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ABSTRACT

To utilize the precious water resources most efficiently, land has to be selected for irrigation according to its suitability for agricultural production. Therefore, the southern Tohama plains were selected to evaluate the soils of the main landforms for sustainable agricultural production using qualitative and quantitative evaluation methods, according to type, number and degree of agriculture limitations such as; texture, effective soil depth, salinity, gravels and calcium carbonate content..etc. This study was carried out in 2004-2008 as part of a project aimed to "Survey of soil resources and water quality evaluation in Southern Tohama plains, Saudi Arabia". The Tohama plains have important geomorphologic features in the south western region of Saudi Arabia, which receive relatively high quantities of runoff water from the surrounding hills. Soils of Southern Tohama plains are the most important source of available land resources for sustainable agriculture development in the region. Four hundred eighty four soil profiles representing the main landforms were examined. Soil characteristics were rated for different systems of irrigated agriculture according to the recommended methods. Generally, the unsuitable soils for agriculture (N1 and N2) occupied varying areas in the dominant landforms in the study area as follows: Sabkhat (61%), Coastal plains (20%), Wadis (22%) and Footslopes (23%). While, the different suitable classes for irrigated agriculture occupied most of the dominant landforms such as alluvial plain, alluvial fans ...etc. Also, the results showed that the high suitable soils represent 13% of total area, while most of the area includes suitable soils with restriction (36% of total area). The unsuitable soils represent less area (2.2%).

Key words: landforms, land suitability, Saudi Arabia, Tohama plains.

1. INTRODUCTION

Considering the rapid growth of the world populations, which is in its turn a limiting factor to the arable lands around the world, the dire need for effective and efficient application of the croplands has been felt more than ever. Sustainable agriculture would be achieved if lands can be categorized and utilized based upon their different uses (FAO, 1983, 1984).

Problems caused by immethodical and unsuitable using of lands, irregular development of urban areas and therefore reduction in cultivation zones have received widespread attention throughout the world. Using of optimum and suitable methods of lands is the main concern of policy makers for the sustainable planning and management most of the cultivation areas. Hence, studies related to land suitability evaluation will provide sustainable using agricultural lands (Rahimi *et al.,* 2009). The capacity of land to produce plants is subjected to some limitation. The limits for production are set by soil, landform, water supply and climate conditions and the use and management applied to the land. Accordingly, knowledge of land resource endowments and their production potential is an essential prerequisite for planning optimal land use in changeable socio-economic scenarios. This knowledge is equally important to effect the desired change *i.e.* agricultural and economic development that could be sustained for a reasonably long time (FAO, 1993).

The fundamental principle of land evaluation is to estimate the potential of a land for different productive uses, such as farming, livestock production, or forestry, together with uses that provide services or other benefits, such as water catchment, recreation, tourism and wildlife conservation (Dent and Young, 1981). Consequently, land evaluation is a tool for

strategic land use planning. A specific agricultural use and management system on land that is most suitable according to agro-ecological potentialities and limitations is the best way to achieve sustainability (FAO, 1978).

The most widely used approaches for suitability classification for a particular use are discussed using FAO's framework for land evaluation (FAO, 1976) and Sys (1979). The basic data used in both systems for evaluating land suitability for specific crops and the kind of irrigation and management levels include topography, soils, water and other features such as infrastructure, markets and socio-economic conditions. In the Kingdom of Saudi Arabia several studies were carried out to classify soils (Mashhady *et al.,* 1986; Ministry of Agriculture and Water 1985 and 1995; Al-Malik, 1994 and Al-Sheikh *et al.,* 1995).

The suitability of a given piece of land is its natural ability to support a specific purpose. According to the FAO methodology (1976), this is strongly related to the "land qualities" such as 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 later values to study the suitability. Thus, the land characteristic parameters were used to workout land suitability for irrigation, crops and forest. The land suitability classification consists of assessing and grouping the land types in orders and classes according to their aptitude. Sys *et al.* (1991) applied the concept of FAO and assessed the land in irrigated and rainfed area. Data on crop requirements are also provided (Sys *et al.*, 1993).

The western coastal lowlands of Saudi Arabia, locally called Tohama, form a narrow strip along the Red Sea coast. In the north, it starts as a narrow plain near Al Wajh and gradually broadens to more than 40 Km near Gizan in the south. The Tohama is low depositional surface mostly on a coral plain that grades upwards to the east to form a pediment on hard crystalline rock of the geologic basement. Along its eastern edge the coastal plain is set apart from the highlands by an escarpment wall, which runs parallel to the sea. The landforms, developed in this region, are mainly of alluvial nature, formed as a result of the downward transportation of soil material from the highlands by the many wadis and drainage channels that drain out in the sea. The watercourses are gently sloping and short, with the

exception of wadi al Hamd, near Madinah, which extends inland to a long distance. Landforms in the forms of alluvial fans, alluvial plains, deltas or forms of footslopes of colluvial nature are common. Along the shore, tidal flats and beaches are developed by tidal activities of the sea (Ministry of Agriculture and Water, 1995). General survey was conducted on the soil of Saudi Arabia (Ministry of Agriculture and Water, 1995), the report included an assessment for the land resources. Also, the report pointed out that each land resource unit is evaluated for its suitability for general cropping and 33 specific crops under two relevant modes of irrigation, *i.e.* surface or overhead means. In high rainfall areas, such as terraced slopes in the Asir mountains, land potential for rainfed cultivation is also assessed. For irrigation, land suitability for the crops is determined with various assumptions about groundwater, including its availability (or otherwise) and diverse qualities of the water.

The main objective of the current study was to evaluate the soils of the main landforms of Tohama plains in the southwestern region of Saudi Arabia for sustainable agricultural production using qualitative and quantitative evaluation methods, according to type, number and degree of agriculture limitations such as; texture, effective soil depth, salinity, gravels and calcium carbonate content..etc. This appraisal is designed to assist the development planners in identifying and assessing areas suitable for agricultural production.

2. MATERIALS AND METHODS
2.1. Description of the study area

Tohama plains are one of the more promising areas in the Kingdom for future sustainable agriculture development, where the requirements for sustainability exist including renewable surface water resources and deep fertile soils. In addition, the region is one of the oldest agriculture areas in Saudi Arabia with accumulated experience for successfully cultivating field crops, vegetables and fruit trees. The region has worm summer and temperate winter that are suitable for promising agriculture development for traditional and intensive cultivations. The relatively high annual rainfalls, particularly in the surrounding mountains are the main renewable water resource that causing occasion flooding in the wadis and plains in Tohama. The study area is located between the international boarders of Saudi Arabia with Yemen (Latitude 16º 24´ 26″ N) and north Wadi Rim (17º 48´ 29.9″ N) with a length of

170 Km and a mean width of 30 Km, the total area is 8165 Km^2 (Fig. 1). The area was occupied by weathered products of igneous and metamorphic rocks. These rocks could be grouped into three formations; granite, basalt and schist and they constitute the main source of soil parent materials. The meteorological data (Ministry of Agriculture and Water, 1988) indicated that the annual average rainfall, temperature and relative humidity were 100 – 200 mm/year, 21 - 40 °C and 85 %, respectively. The main source of irrigation water is the underground water from aquifer. Generally, the total soluble salts of the ground water have high water quality ($EC_{iw} < 3.0$ dSm^{-1}) (Al-Turki *et al.,* 2008).

2.2. Field study and laboratory analyses

Soil properties (morphological, physical and chemical), water characteristics and climatological data of the study area were derived from a semi-detailed soil study regarding Tohama plains. The total soil profiles were accounted as 484 profiles, representing twelve geomorphic units encountered in the study area. (Al-Turki *et al.,* 2008). The main objective of this study was to survey of land resources and evaluation of water quality in southern Tohama plain (Al-Turki *et al.,* 2008).

Fig. (1). Location of the study area.

These soil characteristics were rated for irrigated agriculture according to Sys and Verheye (1978), different systems of irrigation according to FAO (1979 and 1983). The land evaluation was determined based upon topography (t), Depth (s2) (s2'= for bedrock, s2 for water table), Drainage (w), Texture (s1).(s1'= 0 – 25 cm, s1= >25 cm depth), Coarse fragments (s4) (s4'= 0-25cm, S4= >25cm depth), Salinity & Alkalinity (n), and $CaCO_3$ % (s3). 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 matter (%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 requirements without further limitation, thus, fertility properties can be excluded from land evaluation with the purpose of irrigation.

3. RESULTS AND DISCUSSIONS

The two systems of land evaluation were tested in this study, they are:
- The parametric evaluation system for irrigated agriculture according to Sys and Verheye (1978).
- The qualitative evaluation system for irrigation according to FAO (1979 and 1983).

The two classification systems were based on FAO framework categorical levels; *i.e.:*

1- Land suitability order (S, N); reflecting kind of suitability.

2- Land suitability classes (S1, S2, S3, N1, N2); reflecting degrees of suitability.

3- Land suitability subclasses ($S2_{(..)}$); reflecting kinds of limitations or main kinds of improvement measures required within classes.

4- Land suitability units; reflecting minor differences in required management within subclasses.

The evaluation relies on standard land characteristics including environmental, physical, chemical and fertility soil characteristics as follows:

1- Environmental factors; climate (c), topography (t) and drainage (w).

2- Physical soil characteristics (s); texture / structure (s1), effective soil depth (s2), carbonate content (s3) and rock fragments (s4).

3- Chemical soil characteristics (n); EC and ESP.

4- Fertility soil characteristics (f); pH (f1), organic matter (f2), sum of basic cations (f3) and apparent CEC (f4).

3.1. The parametric evaluation system according to Sys and Verheye (1978)

This system aims to evaluate land suitability for irrigated agriculture. The different land characteristics that influence the soil suitability for irrigation are rated and capability index for irrigation (Ci) is calculated according to the formula:

$Ci = t. w/100. s1/100. s2/100. s3/100. s4/100. n/100$

The capability classes are defined according to the intensity of soil limitations and the value of the capability index (Ci), Table (1).

content of the top 30 cm is less than 50%. If higher the weighted average of the upper 30 cm is considered only.

The evaluation of land characteristics can be achieved in a relative limitation scale where five

Table (1): Criteria for the determination of the land suitability classes.

Class	Capability index (Ci)	Criteria
S1: Very suitable	>75	Land units with no or only 3/4 slight limitations.
S2:Moderately suitable	50 – 75	Land units with slight and no more than 2/3 moderate limitations.
S3 Marginally suitable	25 – 50	Land units with more than 2/3 moderate limitations and no more than 1 severe limitation that however doesn't excludes the use of the land.
N1: Not suitable	<25	Land units with severe limitation that can be corrected.
N2: Not suitable	<25	Land units with severe and /or very severe limitation that can't be corrected.

In this system, the land characteristics to be used for evaluation are:
- topography (t)
- wetness (w):
 *flooding
 *drainage
- physical soil characteristics:
Texture, effective soil depth, calcium carbonate content, and salinity and alkalinity.

The dominant topographic factor that influences the irrigation suitability, concerns the slope. Wetness limitations are evaluated with regard to drainage conditions and flooding. The criteria for the evaluation of drainage conditions are without or with presence of saline groundwater table. The textural evaluation of the profile is done to the depth of 120 cm, considering that the surface horizon is more important than the subsurface ones. Soil depth is defined as the thickness of the loose soil above a limited layer, which is impermeable for roots or percolating water. The most common types of such limiting layers are:
- an unconsolidation gravelly or stony horizon with at least 75% coarse fragments.
- a continuous, more or less consolidated, calcium carbonate or gypsiferous layer with a minimum thickness of 30 cm and including at least 50% $CaCO_3$ or gypsum.
- a continuous hard rock or hardpan of more than 10 cm thick.

The criteria to evaluate $CaCO_3$ status depend on the weighted average of the profile until the depth of 1 m or up to a limited layer if the $CaCO_3$

levels are used, Table (2).

Table (2): Limitation levels and their rating.

Symbol	Intensity of limitation	Rating
0	No	98 – 100
1	Slight	85 – 98
2	Moderate	60 – 85
3	Severe	45 – 60
4	Very severe	<45

Data in Table (3) indicate the different subclasses that could be defined in the soils of the study area according to Sys and Verheye (1978). Due to the large number of soil profiles that represents the dominant landforms in the study area, the study only included a number of soil profiles representing different degrees of suitability within each form of land. While the rest of the soil profiles covered by the current study are located in the report of Al-Turki et al., 2008.

According to (Sys and Verhey 1978) the percentage of studied soil profile belonging to different suitability classes within each landform (of the total studied soil profile represent every landform) was as follows: highly suitable land (S1) land within this class is quite limited (alluvial plain 22%, pediplain with shallow soil 28%, hills and rock outcrops 18%, footslopes 19%, terraced 11%, and alluvial fan 18%). Moderately suitable land (S2) lands within this suitability class have moderate limitations (coastal plain 11%, alluvial plain 34%, wadis 27%, pediplain with deep soil 51%, pediplain with shallow soil 28 %, active

Table (3): Land Suitability for Irrigated Agriculture According to (Sys and Verhey 1978).

Profile No.	t	w	s1	s2	s3	s4	n	C1	Subclass
Sabkhat									
1	$0_{(100)}$	$3_{(55)}$	$2_{(78)}$	$3_{(55)}$	$0_{(100)}$	$S1_{(90)}$	$4_{(45)}$	9.6	$N1_{(n,w)}$
47	$0_{(100)}$	$S1_{(95)}$	$2_{(70)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$3_{(58)}$	38.6	$S3_{(s1,n)}$
48	$0_{(100)}$	$2_{(70)}$	$2_{(77)}$	$S1_{(90)}$	$0_{(100)}$	$0_{(100)}$	$2_{(75)}$	36.4	$S3_{(s1,n,w)}$
63	$S1_{(90)}$	$2_{(70)}$	$3_{(53)}$	$S1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	23.5	$S3_{(s1,w)}$
166	$0_{(100)}$	$3_{(55)}$	$S1_{(90)}$	$2_{(70)}$	$0_{(100)}$	$0_{(100)}$	$2_{(85)}$	29.5	$S3_{(w,n,s2)}$
194	$0_{(100)}$	$3_{(55)}$	$4_{(30)}$	$2_{(70)}$	$S1_{(90)}$	$0_{(100)}$	$2_{(85)}$	8.8	$N1_{(w,s1,n,s2)}$
Coastal plain									
2	$2_{(85)}$	$2_{(80)}$	$3_{(45)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	30.6	$S3_{(si,w,t)}$
17	$3_{(60)}$	$S1_{(86)}$	$2_{(69)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$S1_{(90)}$	31.7	$S3_{(t,s1)}$
24	$0_{(100)}$	$S1_{(95)}$	$S1_{(93)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$3_{(45)}$	39.8	$S3_{(n)}$
46	$S1_{(90)}$	$3_{(45)}$	$3_{(52)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$S1_{(90)}$	19	$N1_{(w,s1)}$
49	$S1_{(90)}$	$3_{(45)}$	$S1_{(91)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(98)}$	36.1	$S3_{(w)}$
180	$0_{(100)}$	$3_{(45)}$	$2_{(82)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$3_{(58)}$	21.4	$N1_{(w,n)}$
188	$0_{(100)}$	$0_{(100)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	75	$S2_{(s1)}$
216	$0_{(100)}$	$2_{(68)}$	$S1_{(93)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	63.2	$S2_{(w)}$
Wadis									
3	$0_{(100)}$	$2_{(60)}$	$3_{(55)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	33	$S3_{(s1,w)}$
25	$0_{(100)}$	$S1_{(95)}$	$2_{(80)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	75	$S2_{(s1)}$
30	$0_{(100)}$	$0_{(100)}$	$3_{(45)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	45	$S3_{(s1)}$
133	$0_{(100)}$	$0_{(100)}$	$S1_{(90)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	90	S1
134	$0_{(100)}$	$0_{(100)}$	$3_{(55)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(98)}$	40.4	$S3_{(s1,s2)}$
162	$0_{(100)}$	$3_{(45)}$	$4_{(40)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	18	$N1_{(W,s1)}$
191	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	75	$S2_{(s2)}$
199	$3_{(50)}$	$3_{(45)}$	$3_{(55)}$	$3_{(55)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	6.8	N2
209	$0_{(100)}$	$3_{(45)}$	$3_{(53)}$	$3_{(55)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	13.1	$N1_{(s2,s1)}$
219	$0_{(100)}$	$3_{(45)}$	$4_{(30)}$	$3_{(55)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	6.7	N2
Alluvial plain									
26	$0_{(100)}$	$2_{(62)}$	$2_{(82)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	50.8	$S2_{(s1,w)}$
27	$0_{(100)}$	$2_{(60)}$	$0_{(98)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	58.8	$S2_{(w)}$
28	$0_{(100)}$	$0_{(100)}$	$3_{(50)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	50.0	$S3_{(s1)}$
31	$0_{(100)}$	$0_{(100)}$	$1_{(96)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	96	S1
32	$0_{(100)}$	$3_{(45)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	33.8	$S3_{(w,s1)}$
38	$2_{(85)}$	$0_{(100)}$	$2_{(75)}$	$0_{(100)}$	$2_{(80)}$	$0_{(100)}$	$0_{(100)}$	50.0	$S3_{(t,S1,S3)}$
40	$0_{(100)}$	$1_{(95)}$	$2_{(65)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	61.8	$S2_{(s1)}$
50	$2_{(85)}$	$3_{(45)}$	$2_{(70)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	26.8	$S3_{(s1,w,t)}$
53	$0_{(100)}$	$0_{(100)}$	$1_{(86)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	86.0	S1
75	$1_{(90)}$	$0_{(100)}$	$3_{(55)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	49.5	$S3_{(s1,t)}$
83	$0_{(100)}$	$0_{(100)}$	$1_{(95)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	71.3	$S2_{(s2)}$
117	$1_{(90)}$	$0_{(100)}$	$1_{(87)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$2_{(75)}$	58.7	$S2_{(n)}$
131	$0_{(100)}$	$3_{(45)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	40.5	$S3_{(w)}$
Pediplain with deep soil									
4	$0_{(100)}$	$1_{(87)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	65.3	$S2_{(s1)}$
5	$0_{(100)}$	$1_{(87)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$2_{(85)}$	66.6	$S2_{(n)}$
6	$0_{(100)}$	$2_{(80)}$	$2_{(78)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	62.4	$S2_{(s1,w)}$
10	$2_{(85)}$	$0_{(100)}$	$3_{(48)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	40.8	$S3_{(s1,t)}$
14	$2_{(85)}$	$0_{(100)}$	$2_{(73)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$3_{(58)}$	36	$S3_{(n,s1,t)}$
20	$2_{(85)}$	$3_{(45)}$	$2_{(60)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	28	$S3_{(w,s1,t)}$
22	$2_{(85)}$	$1_{(92)}$	$2_{(65)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	50.3	$S2_{(s1,t)}$
43	$0_{(100)}$	$3_{(45)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	33.8	$S3_{(s1,w)}$
171	$0_{(100)}$	$1_{(90)}$	$2_{(65)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	58.5	$S2_{(s1,t)}$
Pediplain with shallow soil									
103	$0_{(100)}$	$3_{(45)}$	$1_{(88)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	39.6	$S3_{(w)}$
143	$0_{(100)}$	$0_{(100)}$	$2_{(83)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	83.0	S1
123	$2_{(85)}$	$1_{(90)}$	$2_{(84)}$	$0_{(100)}$	$1_{(90)}$	$0_{(100)}$	$1_{(90)}$	50.1	$S2_{(t,s1)}$
128	$0_{(100)}$	$2_{(70)}$	$2_{(63)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	41.9	$S3_{(s1,w)}$
184	$0_{(100)}$	$2_{(65)}$	$2_{(75)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$2_{(80)}$	29.3	$S3_{(w,s2,n)}$

192	$1_{(90)}$	$3_{(52)}$	$0_{(100)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$2_{(80)}$	28.1	$S3_{(w,s2)}$
Active slope									
70	$0_{(100)}$	$0_{(100)}$	$2_{(79)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(98)}$	73.5	$S2_{(s1)}$
72	$0_{(100)}$	$0_{(100)}$	$1_{(85)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	$2_{(75)}$	57.4	$S2_{(s1,n)}$
Hills and rock outcrops									
57	$0_{(100)}$	$0_{(100)}$	$2_{(83)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	83	S1
94	$2_{(85)}$	$2_{(85)}$	$2_{(79)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$1_{(90)}$	48.8	$S3_{(t,w,s1)}$
114	$1_{(90)}$	$0_{(100)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$1_{(90)}$	60.8	$S2_{(s1)}$
221	$3_{(50)}$	$0_{(100)}$	$1_{(90)}$	$0_{(100)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	40.5	$S3_{(t)}$
224	$3_{(50)}$	$0_{(100)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	37.5	$S3_{(t,s1)}$
Footslope									
36	$2_{(80)}$	$2_{(80)}$	$2_{(77)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	46.2	$S3_{(t, s1,w)}$
37	$3_{(60)}$	$2_{(80)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	43.2	$S3_{(t,w)}$
56	$2_{(70)}$	$0_{(100)}$	$2_{(81)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$1_{(90)}$	50.0	$S3_{(t,s1,n)}$
109	$1_{(90)}$	$0_{(100)}$	$1_{(89)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	60.1	$S2_{(s2)}$
124	$1_{(90)}$	$0_{(100)}$	$1_{(94)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	84.6	S1
141	$1_{(85)}$	$2_{(75)}$	$2_{(69)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$1_{(90)}$	29.7	$S3_{(s1,s2,w,t)}$
146	$1_{(90)}$	$0_{(100)}$	$2_{(77)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	50.8	$S3_{(s1,s2)}$
147	$0_{(100)}$	$1_{(90)}$	$2_{(82)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$1_{(90)}$	63.1	$S2_{(s1)}$
155	$1_{(90)}$	$2_{(75)}$	$2_{(79)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$2_{(75)}$	30	$S3_{(w,s1,s2,n)}$
156	$2_{(85)}$	$0_{(100)}$	$1_{(90)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	72.7	$S2_{(t)}$
169	$2_{(85)}$	$2_{(68)}$	$2_{(68)}$	$3_{(55)}$	$1_{(90)}$	$0_{(100)}$	$1_{(90)}$	17.5	$N1_{(w,s1,t)}$
173	$1_{(90)}$	$2_{(68)}$	$1_{(87)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	53.3	$S2_{(w)}$
174	$0_{(100)}$	$1_{(90)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$2_{(85)}$	72.7	$S2_{(n)}$
183	$1_{(90)}$	$3_{(45)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$1_{(90)}$	27.3	$S3_{(w,s1)}$
186	$0_{(100)}$	$2_{(85)}$	$2_{(83)}$	$2_{(85)}$	$0_{(100)}$	$0_{(100)}$	$2_{(80)}$	54	$S2_{(w,s1,s2)}$
193	$3_{(50)}$	$1_{(90)}$	$1_{(90)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$3_{(85)}$	15.9	$N1_{(t,s2,n)}$
198	$3_{(50)}$	$3_{(45)}$	$2_{(68)}$	$3_{(55)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	7.57	$N1_{(t,s2)}$
205	$0_{(100)}$	$2_{(75)}$	$2_{(82)}$	$3_{(55)}$	$1_{(90)}$	$0_{(100)}$	$2_{(60)}$	16.2	$N1_{(s2,n,w,S3)}$
211	$0_{(100)}$	$0_{(98)}$	$2_{(83)}$	$0_{(100)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	73	$S2_{(s1)}$
220	$3_{(50)}$	$2_{(75)}$	$1_{(90)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	33.8	$S3_{(t,w)}$
223	$3_{(50)}$	$2_{(75)}$	$2_{(81)}$	$4_{(30)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	9.11	$N1_{(t,s2)}$
Terraced									
71	$0_{(100)}$	$0_{(100)}$	$2_{(68)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	68	$S2_{(s1)}$
86	$2_{(85)}$	$0_{(100)}$	$1_{(90)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	72.7	$S2_{(t)}$
105	$1_{(90)}$	$2_{(75)}$	$1_{(91)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	58.4	$S2_{w}$
106	$2_{(85)}$	$0_{(98)}$	$2_{(75)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	59.4	$S2_{(s1,t)}$
110	$1_{(90)}$	$0_{(100)}$	$1_{(85)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	76.7	S1
118	$2_{(85)}$	$0_{(100)}$	$1_{(90)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$3_{(58)}$	42.2	$S3_{(n,t)}$
129	$2_{(85)}$	$0_{(100)}$	$3_{(59)}$	$1_{(95)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	45.2	$S3_{(s1,t)}$
136	$1_{(90)}$	$1_{(87)}$	$2_{(82)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	64.2	$S2_{(s1)}$
148	$1_{(90)}$	$2_{(80)}$	$1_{(94)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	67.7	$S2_{(w)}$
164	$3_{(50)}$	$2_{(80)}$	$2_{(84)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	33.5	$S3_{(t,w,s1)}$
175	$3_{(50)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	37.5	$S3_{(t,w)}$
Lava field and volcanic hills									
225	$3_{(50)}$	$0_{(100)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$1_{(90)}$	42.8	$S3_{(t)}$
226	$3_{(50)}$	$0_{(100)}$	$1_{(95)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	47.5	$S3_{(t)}$
Alluvial fan									
190	$0_{(100)}$	$0_{(100)}$	$2_{(74)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	74	$S2_{(s1,n)}$
197	$0_{(100)}$	$2_{(80)}$	$2_{(75)}$	$2_{(75)}$	$0_{(100)}$	$0_{(100)}$	$2_{(80)}$	48	$S3_{(s1,s2)}$
204	$0_{(100)}$	$2_{(83)}$	$1_{(90)}$	$0_{(100)}$	$2_{(80)}$	$0_{(100)}$	$2_{(80)}$	47.8	$S3_{(w,s3,n)}$
208	$0_{(100)}$	$0_{(100)}$	$2_{(61)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	61	$S2_{(s1)}$
218	$0_{(100)}$	$1_{(95)}$	$2_{(88)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	$0_{(100)}$	83.6	S1

t- Topography   s2- Depth/ cm   n- Salinity and alkalinity   w- Drainage   s3- CaCO$_3$ %

Ci- Capability Index   s1- Texture   s4- Coarse fragments %

slope 100%, hills and rock outcrops 18%, footslopes 26%, terraced 63% and, alluvial fan 36%). Marginally suitable land (S3), lands within this capability class have limitations which in aggregate are severe (sabkhat 39.1%, coastal plain 69%, alluvial plain 44%, wadis 27%, pediplain with deep soil 49%, pediplain with shallow soil 44%, hills and rock outcrops 64%, footslopes 32%, Lava field and volcanic hills 100%, terraced 26% and alluvial fan 46%). Currently not suitable (N1), lands within this class have severe limitations and can not be corrected at currently acceptable cost, these soils require high input levels for leaching salts and improving drainability. After good soil management these soils can be cultivated with highly salt tolerant crops (sabkhat 60.9%, coastal plain 20%, wadis 11% and footslopes 23%). The permentally unsuitable (N2) (wadis 11%).

3.2. The qualitative evaluation system for irrigation according to FAO (1979 and 1983).

In this classification, land classes for irrigation farming are related to the U. S. Bureau of Reclamation (USBR) classes (1951), Table (4).

The system uses six classes collected in three class levels as follows:

- S1, S2 and S3 are considered suitable for any type of irrigation systems (*i. e.* surface, drip and sprinkler), they are particularly suitable for surface irrigation.
- Class Sc is suitable for non- traditional types of irrigation systems (*i. e.* drip and sprinkler).

suitable soils represent less area 16.2% for currently not suitable and 2.2% permanently not suitable of the total area.

The results of soil suitability evaluation showed 6 classes. The high suitable soils represent 13% of total area, while most of the area includes suitable soils with restriction (36% of total area). The non-suitable soils represent less area (2.2%).

In the study area, the results of the two systems are collected in the following land suitability classes:

- Highly suitable land (S1)

Land within this class has no significant limitation to sustained application of a given use or only minor limitations that will not significantly reduce productivity or benefits, and will not raise inputs to unacceptable level. Land units may have 3/4 slight limitations and land indice is higher than 75. In the studied area, land within this class is quite limited, these soils have the requirements of highly suitable land (S1), *i. e.* soil is flat, very deep, well drained, with optimal infiltration rate (1.12 cm/h), silty clay loam textured, rich in organic matter (2.5%), and free of salts (Table 6). The capability index is 96, (Table 3). Gravity irrigation could be easily applied in these soils (S1) (Table 5).

- Moderately suitable land (S2)

Soils within this suitability class have moderate limitations for sustained application of a given use, the limitations will reduce productivity or benefits and increase required inputs to the extent

Table (4): Correction between USBR and FAO land classification.

FAO	Class definition	USBR
S1	Highly suitable	Class 1
S2	Moderately suitable	Class 2
S3	Marginally suitable	Class 3
Sc	Special use	Class 4
N1	Not suitable at present but potentially suitable	Class 5
N2	Actiually and potentially unsuitable	Class 6

- N1 and N2 are unsuitable land for irrigated agriculture.

Table (5) shows the results of the land suitability for irrigation according to FAO (1979 and 1983). While Table (6) shows that the high suitable soils represent 13%, the moderately suitable soils represent 16.8%, the marginally suitable soils represent 15.8 % of the total area, while most of the area includes suitable soils with restriction (36% of total area). The non-

that the overall advantage to be gained from the use will be appreciably inferior to expect on S1 class. Moderately suitable; land may have more than four slight limitations and/or two or three moderate limitations. The land indice mostly situated between 50 and 75. Most of these soils are characterized by flat surface, very deep, loam to clay loam textured, well drained, with optimum or nearly optimum infiltration rates (0.8-7.0 cm/h) and free of salts. Agriculture limitations are

Table (5): Land Suitability for Irrigated Agriculture According to FAO (1979 and 1983).

Profil No.	t	w	s1	s1	s2	s2	S3	s4	s4	n	Subclass
Sabkhat											
1	S1	N1	S1	S1	S1	S3	S1	S1	S1	N1	N1(w,n,s2)
47	S1	S3	S1	S2	S2		S1	S1	S1	N1	N1(n)
48	S1	N1	S1	S2	S3		S1	S1	S1	N1	N1(n,s2)
63	S3	N1	SC	S3	S2		S1	S1	S1	S1	SC(s1,t)
166	S1	N1	S2	S1	S3		S2	S1	S1	SC	N1(w,n,s1)
194	S1	N1	SC	SC	S2		S2	S1	S1	N1	N1(n,w,s1)
Coastal plain											
2	S3	S2	SC	SC	S1	S1	S1	S1	S1	S1	SC(s1,t)
17	SC	S1	S2	S1	S1	S1	S1	S1	S1	S2	SC(t)
24	S1	S1	S1	S1	S1	S1	S1	S1	S1	SC	SC(n)
46	S3	SC	S2	S1		S1	S1	S1	S1	SC	SC(t,w,n)
49	S3	SC	S1	S1		S1	S1	S1	S1	S1	SC(t,w)
180	S1	SC	S1	S1		S1	S2	S1	S1	N1	N1(n,w)
188	S1	S1	S1	S2		S1	S1	S1	S1	S1	S2(s1)
216	S1	S2	S1	S1		S1	S2	S1	S1	S1	S2(w,s3)
Wadis											
3	S1	S2	SC	S1	S1	S1	S1	S1	S1	S1	SC(s1)
25	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
30	S1	S1	S1	SC	S1	S1	S1	S1	S1	S1	SC(s1)
133	S1	S1	S1	S1		S1	S1	S1	S1	S1	S1
134	S1	S1	S1	S1		S3	S1	N2	N2	S2	N2(s4,s2)
162	S1	SC	S3	S2		S1	S1	SC	SC	S1	SC(w,s5)
191	S1	S1	S1	S1		SC	S1	S1	S1	S1	SC(s2)
199	N1	S1	SC	S1		SC	S1	S1	S1	S1	N1(t,s5,s2)
209	S1	S1	S1	SC		N1	S1	S1	S1	S1	N1(s2,s1)
219	S1	S1	SC	SC		N2	S2	S1	S1	S1	N2(s2)
Alluvial plain											
26	S1	S2	S1	S1	S1	S1	S1	S1	S1	S1	S2(w)
27	S1	S2	S1	S1	S1	S1	S1	S1	S1	S1	S2(w)
28	S1	S1	SC	S1	S1	S1	S1	S1	S1	S1	SC(s1)
29	S1	S2	S1	S1	S1	S1	S1	S1	S1	S1	S2(w)
31	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
32	S1	SC	S1	S1	S1	S1	S1	S1	S1	S1	SC(w)
38	S3	S1	S1	S1	S1	S1	SC	S1	S1	S1	SC(t,s3)
40	S1	S1	S1	S2	S1	S1	S1	S1	S1	S1	S2(s1)
50	SC	SC	S2	S2		S1	S1	S1	S1	S1	SC(t,w)
53	S1	S1	S1	S1		S1	S1	S1	S1	S1	S1
75	S3	SC	S1	SC		S1	S1	S1	S1	S1	SC(w,s,t)
83	S1	S1	S1	S1		S2	S1	S1	S1	S1	S2(s2)
117	S3	S1	S1	S1		S1	S1	S2	S1	S3	S3(n,t)
131	S1	S3	S1	S2		S1	S1	S1	S1	S1	S3(w,s1)
Pediplain with deep soil											
4	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
5	S1	S1	S1	S1	S1	S1	S1	S1	S1	S3	S3(n)
6	S1	S1	S1	S1	S1	S1	S1	S1	S2	S1	S2(s4)
10	S3	S1	SC	SC	S1	S1	S1	S1	S1	S1	SC(s1,t)
14	S3	S1	S2	S1	S1	S1	S1	S1	S1	SC	SC(n,t)
20	S3	SC	S3	S1	S1	S1	S1	S1	S1	S1	SC(s1,w,t)
22	S3	S1	S1	S3	S1	S1	S1	S1	S1	S1	S3(s1,t)
43	S1	SC	S1	S2		S1	S1	S1	S1	S1	SC(w)
171	S1	S1	S2	S2		S1	S1	S1	S1	S1	S2(s1,s5)
Pediplain with shallow soil											
103	S1	S3	S1	S1		S1	S1	S1	S1	S1	S3(w)
123	SC	S1	S1	S1		S1	SC	S2	S1	S3	SC(t,s3,s5,N)
128	S1	S2	S2	S2		S1	S1	S1	S1	S1	S2(s1,w)
143	S1	S1	S1	S1		S1	S1	S2	S2	S1	S2(s4)

ID	1	2	3	4	5	6	7	8	9	10	Final
184	S1	S2	S1	S1		S1	S1	SC	SC	S1	SC(s2,w,s5)
192	S3	S3	S1	S1		SC	S1	SC	S1	SC	SC(t,w,s2,s5,n)
Active slope											
70	S1	S1	S1	S2		S1	S1	S1	S1	S2	S2(n,s1)
72	S1	S1	S1	S1		S2	S1	S1	S1	S3	S3(n,s2)
Hills and rock outcrops											
57	S1	S1	S1	S1		S1	S1	S1	S1	S1	S1
94	SC	S2	SC	S1		S1	S1	S1	S1	S2	SC(t,s1)
114	S3	S1	S1	S2		S2	S1	S2	S1	SC	SC(t,s5,n)
221	N1	S1	S1	S1		S1	SC	S1	S1	S1	N1(t,s5,s3)
224	N1	S1	S1	S1		S1	S1	S1	S1	S2	N1(t,s4)
Footslope											
36	S3	S1	S2	S1	S1	S1	S1	SC	S1	S1	SC
37	SC	S1	S1	S1	S1	S1	S1	S1	S1	S1	SC(t)
56	N1	S1	S1	S2		S1	S1	S1	S1	S3	N1(t,s5,n)
109	S3	S1	S1	S1		S2	S1	S1	S3	S1	SC(t,s5)
124	S3	S1	S1	S1		S1	S1	S1	S1	S1	SC(t,s5)
140	S1	S1	S1	S1		S1	S1	S1	S1	S1	S1
141	SC	S2	S1	S2		S2	S1	S2	SC	S3	SC(t,s5,n)
146	S3	S1	S1	S1		S2	S1	SC	SC	S2	SC(t,s5)
147	S1	S1	S1	S1		S1	S1	S1	N1	S3	N1(s4,n)
155	S3	S2	S1	S2		S3	S1	S1	S1	N1	N1(t,n,s2)
156	SC	S1	S1	S1		S1	S1	S1	S1	S1	SC(t,s5)
169	SC	S2	S1	S1		N1	S2	SC	S3	S3	N1(t,s5,s2,n)
173	S3	S2	S1	S1		S1	S1	S1	S1	S1	S3(t,w)
174	S1	S1	S1	S1		S1	S1	S1	S1	S3	S3(n)
183	S3	S3	S1	S2		S1	S1	S1	S1	S3	N1(t,w,n,s5)
186	S1	S2	S1	S2		SC	S1	S1	S1	S3	SC(s2,n)
193	N1	S1	S1	S1		SC	S2	S1	S1	N1	N1(t,s2,n)
198	N1	SC	S2	S2		SC	SC	S1	S1	S1	N1(t,w,s2,s3)
205	S1	S2	S1	S1		N1	N1	S1	S1	N1	N1(s2,s3,n)
211	S1	S1	S1	S1		S1	S2	S1	S1	S1	S2(s3)
220	N1	S2	S1	S1		S1	S1	S1	S1	S2	N1(t,s5)
223	N1	S2	S1	S2		N1	S1	S1	S1	S1	N1(t,s2,s5)
Terraced											
71	S1	S1	S1	S2		S1	S1	S2	S1	S1	S3(s4)
86	SC	S1	S1	S1		S1	S1	S1	S1	S1	SC(t)
93	S3	S1	S1	S2		S1	S1	S1	S1	S1	S3(t)
105	S3	S2	S1	S1		S1	S1	S1	S1	S1	S3(t,s5)
106	SC	S1	S2	S2		S1	S1	S1	S1	S1	S3(t,s5)
110	S3	S1	S1	S1		S1	S1	S2	S2	S1	S3(t,s5)
118	SC	S1	S1	S1		S1	S1	S1	S1	N1	SC(t,s5,n)
129	SC	S1	S1	S2		S1	S3	S2	S2	S1	SC(t,s5,s3)
136	S3	S1	S1	S1		S1	S1	S1	S1	S1	S3(t)
148	S3	S2	S1	S1		S1	S1	S1	S1	S1	S3(t)
164	N1	S2	S1	S1		S1	S1	S2	S3	S1	N2(t,s5)
175	N1	S2	S1	S1		S1	S1	S1	S1	S1	N1(t)
Lava field and volcanic hills											
225	N1	S1	S1	S1		S1	S1	SC	SC	S3	N1(t,s5,n)
226	N1	S1	S1	S1		S1	S1	SC	S2	S1	N1(t,s4)
Alluvial fan											
190	S1	S1	S2	S2		S1	S1	S1	S1	S1	S2(s1)
197	S1	S2	SC	S1		SC	S1	S1	S1	S3	SC(s2,n)
204	S1	S2	SC	S1		S1	N1	S1	S1	N1	N1(s3,n)
208	S1	S1	S1	S2		S1	S1	S1	S1	S1	S2(s1)
218	S1	S1	S1	S1		S1	S1	S1	S1	S1	S1

t- Topography   s2- Depth (s2'= for bedrock, s2 for water table)   w- Drainage   s3- CaCO3 %

s1- Texture.(s1'= 0 – 25 cm, s1= >25 cm depth) s4- Coarse fragments (s4'= 0-25cm, S4= >25cm depth)   n- Salinity & Alkalini

Table (6):Total area and area of different suitability classes of irrigated agriculture and their ratios, according to FAO (1979 and 1983).

Suitability classes	Area (km 2)	% Of the total area
Highly suitable (S1)	1059.1	13.0
Moderately suitable (S2)	1372.2	16.8
Marginally suitable (S3)	1287	15.8
Suitable with restriction (SC)	2938.9	36.0
Currently not suitable (N1)	1326.8	16.2
Permentally not suitable (N2)	181.2	2.2
Total area	8165.2	100.0

mostly ascribed to the presence of one or two than four slight limitations and/or two or three moderate limitations. The land indice mostly situated between 50 and 75. Most of these soils are characterized by flat surface, very deep, loam to clay loam textured, well drained, with optimum or nearly optimum infiltration rates (0.8-7.0 cm/h) and free of salts. Agriculture limitations are mostly ascribed to the presence of one or two moderate limitations with regard to (Table 3):

- Texture is sandy loam as in some soils of wadis pediplain with deep soils and alluvial plain. Land indice varies between 61.8 and 75, so subclass S2 $_{(s1)}$ is suggested.
- Salinity is medium as in some soils of pediplain with deep soils. Land indice is 66.6 and subclass S2$_{(n)}$ is suggested.
- Infiltration rate is rather slow (0.21-0.43 cm/h) as in some soils of pediplain with deep soils and alluvial plain. Land indice lies between 50.3 and 63 and subclass S2$_{(s1, w)}$ is suggested.
- Marginally suitable land (S3)

Soils within this capability class have limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits or increase required inputs. The land have more than 2/3 moderate limitations and no more than 1 severe limitation that however does not exclude the use of the land. The land indice ranges between 25 and 50. Soils within this capability class need special management that will increase largely inputs, in addition, choice for plants to be utilized and benefits expected are low. At the area under consideration, most of the studied soil profiles could be classified as marginally suitable including soils of Coastal plain, soils of wadis, soils of pediplain with deep soils, soils of alluvial plain, and soils of footslopes.

Agriculture limitations include moderate or severe limitations with regard to:

1- Salinity is severe as represented by the cultivated localities at the coastal plain and pediplain with deep soils.

2- Low available moisture capacity (texture is sand or loamy sand) as shown in soils of the coastal plain, wadis, pediplain with deep soils and the alluvial plain.

3- Rock fragments at surface are 37 and 76%.

4- Topography is undulating or rolling as shown in soils of the coastal plain pediplain with deep soils and footslopes.

5- Carbonate content is severe (64.8%) as shown in the (alluvial plain).

6- Infiltration rate is very rapid (11-19.44 cm/h) as in soil profiles.

Based on these agriculture limitations the following subclasses could be defined, Table (3):

S3$_{(n)}$ Represents the marginally suitable land for irrigated agriculture due to salinity severe limitation. It occupies the cultivated localities at the coastal plain. The capability index is 38.8.

S3$_{(n, s1, t)}$ Represents the soils have in addition to severe salinity, moderate limitations due to texture (SL) and topography (undulating). Land capability indice is 36.

S3$_{(s1)}$ These soils have severe texture limitation (LS). Capability index varies between 42.8 and 50.

S3$_{(s1, t)}$ Represents soils have in addition to severe texture limitation (loamy sand), moderate limitation due to undulating topography as in soils of pediplain with deep soils and wadis. The land indice lies between 31.7 and 50.3

S3$_{(w, s1)}$ Represents soils have severe limitation due to rapid infiltration rate and moderate texture as shown in some soil wadis and alluvial plain.The capability index ranges from 27 to 48.2

S3$_{(t, w)}$ Represents the marginally suitable land which are characterized by rolling topography as severe limitation and rather slow infiltration rate (0.43cm/h) as moderate limitation (footslopes). The capability index is 43.2

S3$_{(t, s1, s3)}$ Represents the marginally suitable land with moderate limitations due to undulating topography, moderately coarse textured (SL)

and high $CaCO_3$ content (64.8%) (alluvial plain). The land capability indice is 50

$S3_{(t, sl, w)}$ Represents the marginally suitable land with moderate limitations due to topography (undulating), texture, and drainage (coastal plain, pediplain with deep soils and footslopes).

Soils characterized by severe salinity, rolling topography, subsurface calcic horizon require high input levels for reclamation and good management.

Currently unsuitable land (N1)

These are soils which may be surmountable in time, but which can't be corrected with existing knowledge at currently acceptable cost. Limitations are so severe to preclude successful stained use of the land in the given manner. Limitations of land within this class are so severe to increase largely development cost and decrease choice of plants and the benefits expected to be gained. Soil profiles are deep, sandy loam textured, highly affected with salts, and water table fluctuates between 90 to 130cm. Soil limitations are mainly ascribed with severe salinity and drainabilty. Suitable index less than 15 and subclass $(N1_{nw})$ is suggested for soils, Table (3). From economical point of view, these soils require high input levels for leaching salts and improving drainability. After good soil management these soils can be cultivated with highly salt tolerant crops.

Acknowledgment

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تقييم الأراضي لاستدامة الأنتاجية في سهول تهامة الجنوبية– المملكة العربية السعودية

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ملخص

يتطلب تعظيم الاستفادة من الموارد المائية بأكبر قدر من الكفاءة، أختيار الترب الصالحة للزراعة المروية وفقا لمدى ملاءمتها للإنتاج الزراعي. ولذلك قيمت الترب المصاحبة للأشكال الأرضية السائدة في سهول تهامة الجنوبية لمعرفة مدى صلاحيتها للزراعة المروية من أجل الأنتاج الزراعي المستدام، وذلك بتطبيق نظاميين للتقييم أحدهما وصفي والآخر كمي، اعتماداً على بعض المحددات مثل القوام وعمق التربة والملوحة والحصى والمحتوى من كربونات الكالسيوم وغيرها. وقد أجريت هذه الدراسة في الفترة من ٢٠٠٤ وحتى ٢٠٠٨؛ كجزء من مشروع بعنوان" حصر الموارد الأرضية وتقييم جودة المياه في سهول تهامة الجنوبية، المملكة العربية السعودية". وتعتبر سهول تهامة من السمات الجيومورفولوجية الهامة في المنطقة الجنوبية الغربية من المملكة العربية السعودية، التي تتلقى كميات عالية نسبيا من مياه الجريان السطحي من المرتفعات المحيطة بها. وتمثل ترب سهول تهامة الجنوبية أهم مصدر للموارد الأرضية المتاحة للتنمية الزراعة المستدامة في المنطقة. تمَ فحص (٤٨٤) قطاع تربة تمثل الأشكال الأرضية الرئيسية. ولتقييم خصائص التربة لأنظمة مختلفة من الزراعة المروية وفقا للأساليب الموصى بها. وبصفة عامة، شغلت التربة غير الصالحة للزراعة (N1 و N2) مختلف المناطق في الأشكال الأرضية السائدة في منطقة الدراسة على النحو التالي: سبخة (٦١٪)، السهل الساحلي (٢٠٪)، الوديان (٢٢٪) والمنحدرات السفلية (٢٣٪). في حين، شغلت مختلف اقسام التربة الصالحة للزراعة المروية معظم الأشكال الأرضية السائدة مثل السهول الرسوبية والمراوح الفيضية .. الخ. كما أظهرت النتائج أن التربة عالية الصالحية تمثل ١٣٪ من المساحة الكلية، في حين شغلت التربة الصالحة للزراعة المروية تحت ظروف خاصة (٣٦٪ من المساحة الكلية)، في حين كانت التربة غير صالحة للزراعة المروية أقل مساحة (٢.٢٪).