SOIL RESOURCE APPRAISAL OF EMIRATE OF DUBAI FOR OPTIMUM LANDUSE PLANNING

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ABSTRACT

Information on soils with regard to their nature, extent and spatial distribution along with their potential and limitations is required for a variety of uses, namely agricultural development, engineering, sanitary, recreation, aesthetic, etc. The soils of Dubai were mapped using remote sensing satellite data (IRS- P6 LISS IV) at 1: 25,000 scale and were classified upto series level and their associations as per the Keys to Soil Taxonomy (USDA, 2003). In Dubai 39 soil series have been identified. The soils of Dubai area are generally coarse textured, (sandy) highly calcareous and undeveloped. The soils of the inland areas are either saline or sodic whereas the soils in the hilly area of Hatta area are characterized by steep side slopes and devoid of vegetation and are highly calcareous. The other features of the soils occurring in the study area are discussed in this paper. The soils have major limitations of climate and soils, which can be improved by adopting various soil conservation measures like sand dune stabilization, shelter belts, afforestation etc.

1. INTRODUCTION

There is evidence to show that a majority of land resources world over are under pressure and are undergoing degradation at an unacceptable rate. The situation in Dubai Emirate is no different. Moreover, Dubai being located in an arid desert belt, it is highly sensitive to a number of critical environmental issues. Soil is one such important issue, as it is a non-renewable natural resource. Soil is in-fact at the heart of terrestrial ecology and is vital to our very existence. Information on soils with regard to their nature, extent and spatial distribution along with their potential and limitations is required for a variety of uses, namely agriculture, engineering, sanitary, recreation, landscaping, etc. In addition, such information is also required for modeling and environmental impact analysis.

Therefore, it is imperative that we manage and conserve soils judiciously to meet the growing need for food, fodder, fibre and fuel. For this purpose, we must have an in-depth knowledge about different soils, their morphology, characterization, behaviour, kind and degree of problem and their extent and distribution in the landscape. This can be achieved through soil survey and mapping, the scales of mapping however depends on the purpose and type of terrain. The soil surveys can be carried out using the modern technology of space borne remote sensing. In-fact this technique has proved to be a powerful tool, because it enables to study resources in spatial domain in time and cost effective manner. Therefore, remote sensing techniques are now operationally used for studying soil resources. Survey of literature reveals that satellite data of LANDSAT MSS / TM, SPOT, IRS LISS I, II, III, IV and PAN and IKONOS etc. were used to map soils at different scales from 1: 250000 to 1: 12500 scales.

The information on soil resources was generated by understanding of the spectral response pattern of soils (Westin and Frazee,1976; Dwivedi , 1985) . The studies with Landsat TM, SPOT and IRS satellites had set the trends of rapid development and wider acceptability of remote sensing application in soil resources study. (Biswas 1987; Frazier and Cheng 1989; NRSA and AIS&LUS 1986). Similar studies have been conducted using SPOT HRV (Agbu,1991) and Indian Remote Sensing Satellite (IRS-IA, IRS 1B, IRS IC/ID) Linear image self scanning sensor (LISS-I, LISS-II- LISS-III) data (Rao *et al* 1998; Rao *et al* 2001).

National Remote Sensing Agency, Hyderabad has prepared soil maps at 1:50,000 scale on operational basis (NRSA 1995, NRSA 1996, NRSA 2001, NRSA 2002) in various parts of the country for various user Departments like Agriculture, Command Area Authorities, etc. The soil mapping was carried out for specific purposes like land capability classification, land irrigability assessment, optimum land use planning etc.

To address the critical environmental issues, the UAE government and the Dubai Municipality, have taken various measures. They have in fact, considered environment protection as one of the prerequisites for its development. In this endeavor, National Remote Sensing Agency, Hyderabad has prepared an inventory of soil resources of Dubai Emirate on the request of Dubai Municipality.

2. STUDY AREA

The project area (Dubai Emirate) covers an area of 4000 sq km. The overall climate of the Emirates is subtropical, warm and arid. Air temperatures range between 35^0 to 50^0 C from May to October during the middle of the day and between 20^0 to 35^0 at mid-day during the winter months. In the interior of the desert, the highest temperatures on the ground during summer rise to 70^0C and the lowest may fall below 0^0C during winter months. The average annual rainfall of the Emirate is less than 100 mm and it occurs mostly during winter months. Some monsoon showers are also received during summer months on the east coast and in the mountain belt that form the watershed between the Arabian Gulf and the Gulf of Oman. The rainfall, however, is very erratic and varies extremely both from year to year and place to place. Some moisture also condenses in the form of fog and dew, especially in the coastal belts. Strong winds and sand storms are also of common occurrence throughout the Emirate. They are especially more frequent and severe during summer months. Sand dunes are the dominant feature of the landscape over most of the Emirate.

3.METHODOLOGY

The soil map of Dubai and Hatta was prepared at 1: 25,000 scale using the Indian Remote sensing Satellite (IRS-ID) Linear Imaging Self Scanning Sensor (LISS IV) data . The soils of the study area were classified as per USDA (2003) upto soil series and their association level. Besides the satellite data ,published reports, climatic data were also used.

Essentially soil survey consists of systematic examination, description, classification and mapping of soils of an area and it comprises of a group of interlinked operations involving

- Preliminary visual interpretation of satellite data
- Fieldwork to study important characteristics of soils and associated land characteristics such as landform, natural vegetation, slope etc.
- Laboratory analysis to support and supplement the field observations.
- Correlation and classification of soils into defined taxonomic units.
- Mapping of soils - that is establishing and drawing soil boundaries of different kinds of soils on standard geographical base map.

3.1 Preliminary visual interpretation

The steps involved in pre-field interpretation is monoscopic visual interpretation of Indian Remote Sensing Satellite (IRS) ID LISS-III and IRS P6 LISS IV data at 1: 25,000 scale based on the standard remote sensing techniques using image characteristics such as tone, texture, pattern, shape, size, association etc. in conjunction with the collateral information available in the form of published maps and reports.

On screen visual interpretation was carried out on the analog satellite data. Satellite data was subjected to different image enhancement techniques so as to derive maximum information. The correlation, thus observed is validated in the field. Having delineated broad physiographic units and the underlying parent material, further divisions within these units were made based on land use / land cover, slope, erosion, drainage pattern and image elements such as tone, texture, size, pattern, shape and association.

A tentative interpretation key in terms of lithology, physiography, land use/ land cover, erosion /salinity / alkalinity hazards and image elements was developed. Sample strips representing ample variation in the delineated physiographic units were selected for field verification. The location of sample strips was transferred onto the base map for precisely locating them on the ground.

3.2 Field work

A field visit was undertaken in Dubai, to study important characteristics of soils and associated land features for mapping soils .A preliminary study on the landform, geology, climate and vegetation of the study area was undertaken. After these preliminary studies, the survey work was undertaken with the objective to study soils under natural condition and to prepare a mapping legend based on soil properties.
The detailed soil-site study was undertaken in each soil-mapping unit by general traversing and by collecting surface soil, minipit and soil profile observations at intervals depending on soil variability. The soil profiles /pedons (A vertical cut from the surface down to the hard rock from which the soil is formed gives the soil profile and in the profile several successive characteristic layers can be identified) were studied by digging pits of approximately 1 x 0.5 x 1 m in dimension (length, width, depth) at representative areas. Each of these layers (horizons) was studied for various morphological features such as colour, texture, structure, consistency etc. The depth to bedrock or compact layer was determined. External features such as slope, erosion, surface stones etc were also noted. The frequent profile sampling enabled to determine the depth of various horizons and also the horizons of gains (illuvial) and losses (eluvial). Observations on land use, land cover were also noted.

3.3 Laboratory analysis

Laboratory analysis was carried out for the soil samples collected during the field work. All the physical and chemical properties were carried out in the lab as per the standard international procedures.

3.4 Post field interpretation

Preliminary interpreted soil boundaries from IRS-P6 were modified using field information and final thematic details were transferred on to the base map. Finally the soils were classified in the light of soil morphology features, soil physical and chemical properties as described in soil survey procedure (USDA, 2003). Thus, the landscape map was converted into soil scape map in terms of soil series and / associations thereof.

4. RESULTS AND DISCUSSION

4.1 Soils and their classification

The relationship between physiography of an area and soils has been widely recognized as the factors involved in the physiographic processes correspond close to that of soil formation. This relationship between landscape features and soil conditions makes possible for prediction about nature and distribution pattern of different soils. The present soil-scape is the result of different geomorphic processes that have taken place in the past and modified the soil-scape in its present manifestation.

Sufficient observations in the form of profiles, minipits, have been recorded for the study. Based on the variations in the soil and site characteristics 26 soil series have been identified in Dubai area and 13 series in Hatta area.

4.2 Description of soils

The soils are generally coarse, sandy, highly calcareous and undeveloped. They are deficient in organic matter. Soils in the coastal belt and low-lying areas and depressions are highly saline and where as the soils in the interior of the desert are either saline or sodic.

The major Landscapes identified in the study area are coastal plain, lower aeolian plain and upper aeolian plain. These major landscape units were further subdivided into different physiographic units such as Beach, tidal flats/ mudflats, salt flats (young and old) and dunes over the coastal plain The lower aelion plain has low sand dunes,

longitudinal dunes, interdunal flat areas (sandy , saline & sodic), dunal complex areas and residual hills and linear ridge. The upper aelion plain has dunal complex, interdunal flats (Sandy and sodic) low sand dunes. The soil map of Dubai is shown in Figure 1 . Table 1 shows the different soil mapping units encountered in the study area along with their description and areal extent.

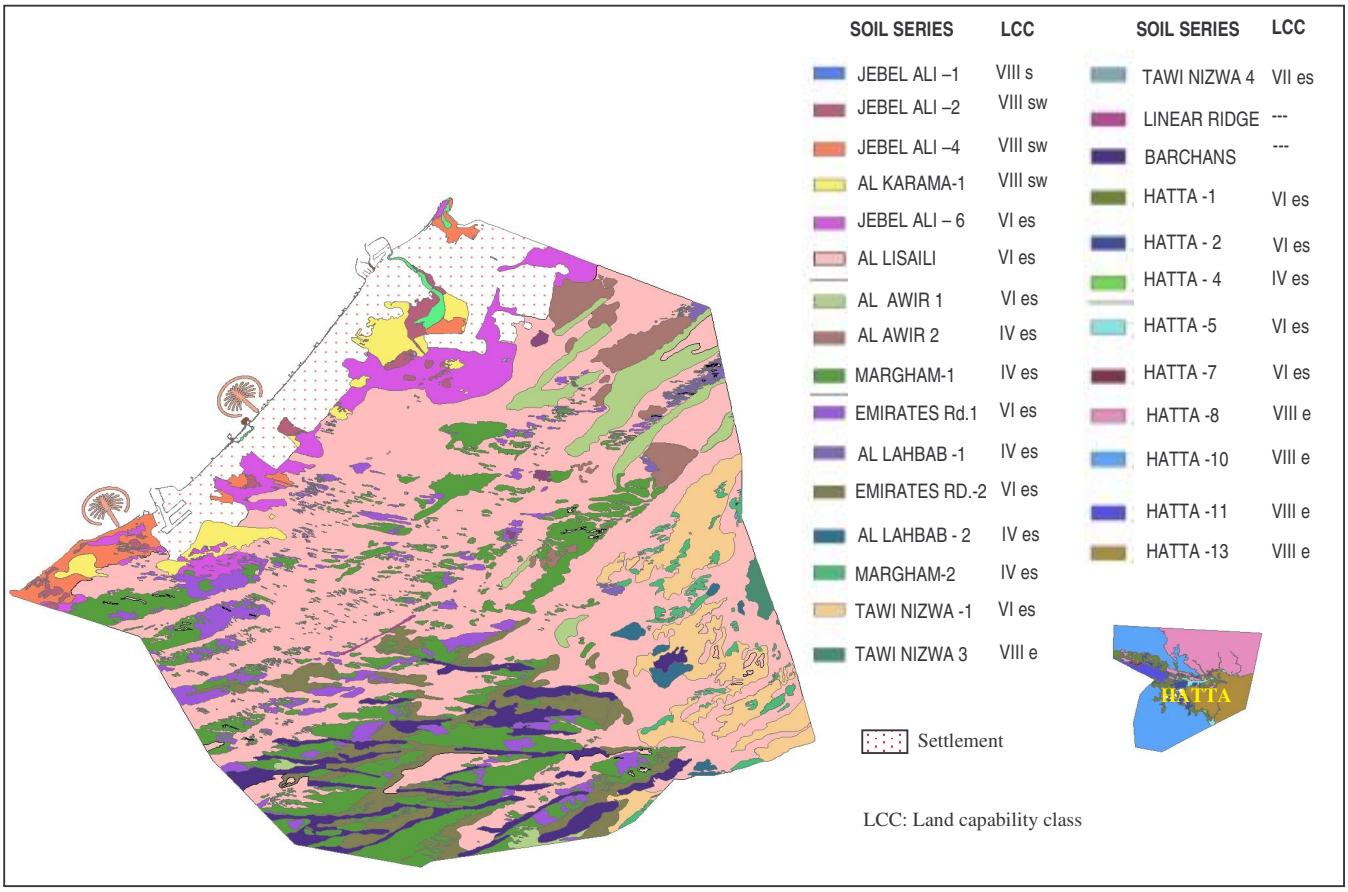

Figure 1 Soil map of Dubai emirate

In the hilly area of Hatta the major Physiography units identified are structural valley region, piedmont area residual hills, denudational hills (Periodite/ dunite/ gabbro), denudational hills (limestone /dolomite/marble) and structural hills (periodite/ dunite / gabbrointerbedded),The soil temperature regime of Dubai is hyperthermic, The soil moisture regime is aridic / torric. In general all the soils of Dubai are calcareous. As the study area falls under arid region the soils occurring in these areas will normally have an aridic (torric) moisture regime. On analysis of all the soil samples collected during the ground truth, it can be inferred that all the soils of Dubai and Hatta area are calcareous.

4.3 The land capability units in Dubai

The land capability grouping for the study area has been made based on the above mentioned parameters i.e. the grouping the inherent soil characteristics, external land features and environmental factors following the criteria laid down in soil survey manual (All India Soil Survey and land use Survey, 1970). In Dubai area four land capability classes were identified and they are discussed as under.

Land capability Class –IV: These lands have severe limitations due to shallowness, gravel, stone. The major limitation of this land capability unit for carrying out any agricultural practice in the study area is the climate besides, the soils also have shallow soil depth and severe root zone limitations. The units identified under the sub class –IV es are soil mapping unit 8,9, 12 and 14 comprising the soil series namely Al Awir2, Margham, Al Murquab, Al LAhbab-1, Al Lahbab 2 , Al faqa, Margham 2 Margham 3 and Hatta 4. The total area covered under the capability class IV is 68589 hectares and accounts for 17 % of the study area. These lands are marginally suitable for agriculture as the average annual rainfall of Dubai is extremely low < 100 mm per year , agriculture can be taken up only with the support of assured irrigation.

Land capability Class – VI: These lands are also non-arable due to limitations due to severe soil erosion . The areas earmarked under this category include the low sand dunes which are subjected to severe wind erosion, The soil mapping units which are included under this category are 5, 6, 7, 10, 12, and 15 which include the soil series namely; Jebel Ali 6, Al Lisaili, Jumeirah, Al Awir 1, Um Nahad,

Emirates Rd.2, Emirates Rd.1, Tawi Nizwa1 , Tawi Nizwa 2 , Hatta 1, Hatta 2 and Hatta3. The area covered under this sub class (VI es) is 259372 hectares and accounts for 66 % of the study area in Dubai.

Land capability Class – VII: These lands are also non-arable due to limitations of steep slopes, shallow soil depth due to soil erosion. The soil series included under this category is Tawi Nizwa 4,. The area covered under this sub class is 36 hectares and accounts for 0.09 % of the study area.

Land capability class VIII: These lands are non arable and are only suitable for wild life and recreation. The soil mapping units that are classified under this mapping unit are 1,2,3,4 and 16. The soil series included in this category are Jebel Ali 1,Jebel Ali 2, Jebel Ali 3, Jebel Ali 4, Jebel Ali 5, Al Karama 1 and Al Karama 2, and Tawi Nizwa 3. Hatta 8, Hatta 9, Hatta 10, Hatta 11, Hatta 12 and Hatta 13 The area under this land capability unit is 32640 hectares and accounts for 8 % of the study area.

S No	Soil series	Soil description	Soil classification	LCC	Area (Ha)
1	Jebel Ali - 1	Light gray, very deep, some what excessively drained, fine sand, sodic, occurring over nearly level to very gently sloping occurring over , beach.	Typic (sodic) Torripsamments	VIII s	155
2	Jebel Ali- 2) Jebel Ali –3	Light gray, very deep, poorly drained, fine sand with reduced conditions saline; associated with light brownish gray, very deep, imperfectly drained, saline soils occurring over nearly level tidal flats	Typic (saline) Psammaquents Oxyaquic (saline) Torripsamments	VIII sw	3261
3	Jebel Ali –4 Jebel Ali –5	Light gray to light yellowish brown , very deep, poorly drained, sandy loam, highly saline; associated with soils which are grayish brown, very deep, imperfectly drained, loamy sand, highly saline, occurring over nearly level young salt flats.	Typic (saline) Psammaquents Oxyaquic (saline) Torripsamments	VIII sw	6120
4	Al- Karama Al- Karama 2	Light brownish gray, very deep, imperfectly drained, fine sand, highly saline; associated with soils which are light brownish gray, very deep, poorly drained, sandy clay loam, highly saline with reduced conditions; occurring over nearly level old salt flats	Oxyaquic (saline) Torripsamments Fine loamy (saline) Typic Aquicsalids	VIII sw	7695
5	Jebel Ali –6 Al LiSaili	Light yellowish brown, moderately shallow, well drained, fine sand, saline associated with Yellowish brown, moderately shallow, excessively drained, fine sand , sodic, occurring over very gently sloping low dunal coastal plains.	Typic (saline) Torripsamments Typic (sodic) Torripsamments	VI es	16653
6	Al LiSaili Jumeirah	Yellowish brown, moderately shallow, well drained, fine sand, sodic, occurring over low sand dunes associated with soils which are brown, mod.shallow, sandy loam, saline, and some what excessively drained and occurring over gentle slopes of sand dunes.	Typic (sodic) Torripsamments Typic (saline) Torripsamments	VI es	169721
7	Al- Awir 1 Um Nahad	Brown, very deep, excessively drained, fine sand, sodic, associated with soils which are yellowish brown excessively drained, fine sand, sodic, compact horizons, occurring over gentle to moderately sloping dunes.	Typic (sodic) Torripsamments	VI es	13722
8	Al- Awir 2	Brown to yellowish brown, moderately shallow, well-drained, fine sand, slightly sodic with compact horizons occurring over very gently sloping interdunal flats with sand cover.	Typic (sodic) Torripsamments	IV es	9108
9	Margham 1 Al Murquab	**B**rown, very shallow, well drained, gravelly loamy sand, gravelly, saline associated with soils which are yellowish brown, very shallow to shallow, well drained, gravelly, loamy sand, saline and are found occurring over very gently sloping interdunal flats.	Sandy Skeletal (saline) Typic Torriorthents Loamy skeletal (saline) Typic Torriorthents	IV es	51456
10	Emirates Rd -1	Yellowish brown, extremely shallow, well drained, fine sand, gravelly, saline and are found occurring over very gently sloping interdunal flats.	Sandy Skeletal (saline) Typic Torriorthents	VI es	16516
11	Al lahbab 1	Yellowish brown, very shallow, moderately well drained, gravelly fine sand, gravelly, sodic and are found occurring over very gently sloping interdunal flats.	Sandy Skeletal (sodic) Typic Torriorthents	IV es	1731
12	Emirates Rd -2 Al- Lisaili	Brown, moderately shallow, well drained, fine sand associated with yellowish brown, very shallow, well drained, loamy sand, gravelly, saline which are occurring over interdunal flats and dunes	Sandy Skeletal (saline) - Typic Torriorthents Typic (sodic) Torripssamnets	VI es	20639
13	Al lahbab 2	Brown, moderately deep, well drained, fine sand,	Typic (sodic)	IV es	2387

	Al- faqa	sodic, with compact horizons, associated with soils which are brown, deep, moderately well drained slightly gravelly; occurring over very gently sloping interdunal flats with sand cover.	Torripsamments		
14	Margham 2 Margham 3	Brown to yellowish brown, shallow, moderately well drained, fine sand and sodic; associated with soils which are yellowish brown, very shallow, well drained, loamy sand, sodic, gravelly occurring over very gently sloping interdunal flats	Sandy Skeletal (sodic) Typic Torriorthents	IV es	3907
15	Tawi Nizwa 1 Tawi Nizwa 2	Strong brown, very deep, excessively drained, fine sand, sodic; associated with soils which are strong brown, moderately deep, well drained, fine sand, sodic, occurring over gently sloping dunes associated with interdunal flats.	Typic (sodic) Torripsamments Sandy (sodic) Typic Torriorthents	VI es	19946
16	Tawi Nizwa 3	Loose sand Reddish brown, very deep, excessively drained, fine sand , sodic,with surface covered by iron and manganese concretions and occurring over piedmont covered with sand dunes.	Typic (sodic) Torripsamments	VIII e	1513
17	Tawi Nizwa 4	Brown, shallow, well-drained, fine sand, sodic, gravelly occurring over hillside slopes (8-15%) with sand dune cover.	Rock outcrops Sandy Skeletal (sodic) Typic Torriorthents	VII es	36
18	Linear Ridge				205
19	Barchans				17411
20	Hatta –1 Hatta –2	Brown, very shallow, well drained, loamy sand, skeletal & stony, surface covered with stones (>75%) associated with brown, very shallow, well drained, gravelly sand, stony and occurring over the structural valley region.	Loamy skeletal Typic Torriorthents Sandy skeletal Typic Torriorthents	VI es	1289
21	Hatta –2 Hatta –3	Brown, very shallow, well drained, sand, stony. Associated with brown, very shallow, well drained, loamy sand, skeletal soils with surface covered with stones (>75%) and occurring over the structural valley region.	Sandy skeletal Typic Torriorthents	VI es	552
22	Hatta –4	Dusky red, moderately deep, silty clay loam moderately well drained, gravelly, surface covered with stones 40-75%.	Loamy skeletal Typic Haplocambids	IV es	12
23	Hatta –5 Hatta –6	Dark grayish brown, very shallow, sandy clay loam, well drained associated with brown , very shallow, well drained, gravelly with surface cover of stones (>75%) occurring over wadi areas.	Loamy skeletal Fluventic Haplocambids Loamy skeletal Typic Torriorthents	VI es	280
24	Hatta –7	Brown, very shallow-to-shallow, well drained, loam, skeletal soils with surface covered with stones (>75%) and occurring over the piedmont area.	Loamy skeletal Typic Torriorthents	VI es	54
25	Hatta –8 Hatta –9	Barren –rocky (80 – 90%) associated with brown, very shallow, well drained, loamy, skeletal soils with surface covered with stones (>75%) and with dusky red, very shallow, well drained, sand, occurring over side slopes of residual hills (Shales)	Loamy skeletal Typic Torriorthents Sandy skeletal Lithic Torriorthents	VIII e	4771
26	Hatta –10	Barren –rocky (80 – 90%) associated with brown, very shallow, well drained, sandy loam, skeletal soils with surface covered with stones (>75%) occurring over steep side slopes of denudational hills (Periodite / Dunite / Gabro)	Loamy skeletal Lithic Torriorthents	VIII e	6100
27	Hatta –11 Hatta –12	Barren –rocky (80 – 90%) associated with dark grayish brown to brown, very shallow, well drained, loam, skeletal soils with surface covered with stones (>75%) and with brown, very shallow, well drained, loam, skeletal soils with surface covered with stones occurring over steep side slopes of denudational hills (Lime stone/ Dolomite /Marble)	Loamy skeletal Lithic Torriorthents Loamy skeletal Typic Torriorthents	VIII e	463
28	Hatta –13	Barren –rocky (80 – 90%) associated with dark brown, very shallow, well drained, gravelly loam, skeletal soils with surface covered with stones (>75%) occurring over steep side slopes of structural hills (Periodite/ dunite / gabbro interbedded	Loamy skeletal Lithic Torriorthents	VIII e	2552

Table 1 Description of Soils and their classification

4.4 Salt affected soils

Salt-affected soils are the characteristics of arid-environment. In regions, where precipitation is less than potential evapo-transpiration, the cations released by mineral weathering accumulate because there are not enough rains to thoroughly leach them away. The salt-affected soils occur in Dubai are either saline or sodic in nature. Besides, the quality of ground water varies a great deal in the Emirates. Water in the shallow aquifers derived from annual precipitation or its sub-surface flow from the mountains contains fewer salts. The ground water derived from the deeper aquifers is generally more brackish. The quality of the ground water gradually improves as one moves away from the coast into the interior. If more brackish water is used for irrigation purposesit quickly salinizes the soils.

5 OPTIMAL LAND USE PLAN

During the study various problems and potentials of Dubai were identified. The main problems include very low rainfall, extreme variation in temperature, strong winds and sand storm, very coarse textured soils, poor fertility of soils, soil salinity and sodicity, degradation of natural vegetation, depletion and poor quality of ground water resources etc. Based on the resource constraints prevalent in Dubai, the critical areas can be managed effectively by some of the methods for optimum utilization of available resources. One of the major problem is Shifting sand dunes which occupy great areas in Dubai and therefore present a major problem confronting the development. Roads, habitations, cultivated land and forest plantations are liable to be encroached upon by moving sand and sand dunes in most places in the Dubai Emirates. This encroachment by sand is considerably much more where natural vegetation in the surrounding areas has either been destroyed or depleted (Gupta J.P., 1990). A variety of sand dunes are found in various parts of the Emirate (Mohamed Khan I.R., 2003). They are continually extending, moving or changing their shapes and forms. Some of the measures which are recommended are; control of wind erosion and sand dune stabilization . The other measures which can be adopted for optimal land utilization include, afforestation, development

of pasture lands / silvipasture, horticulture development, management of salt affected soils and identifying the areas suitable for urbanization

6.CONCLUSIONS

The study of soils in the region of Dubai Emirate using high resolution multispectral satellite data has resulted in providing a detailed natural resource inventory outlining the problems and potentials of various soils. As the Emirate is falling under extremely arid area permanent or sustained agriculture is not possible without artificial irrigation.

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