ASSESSING DESERT VEGETATION COVER USING REMOTELY SENSED DATA: A CASE STUDY FROM THE STATE OF QATAR

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ABSTRACT

The state of Qatar with arid climatic conditions and thus has sparsely distributed vegetation cover including mangroves along the coasts. The location of Qatar at the western side of the Arabian Gulf, and being a part of the large landmass of the Arabian Peninsula play an essential role in the make up of floral and faunal diversity. Generally, the sparse inland vegetation in Qatar is comprised of herbaceous plants, dwarf shrubs and few tree species. There are many forces contributing to the vegetation dynamics in Qatar. Increased awareness among the state machineries and general mass about the importance of vegetation contributed to the increase in vegetation cover. On the contrary continuous infrastructure development, settlements and industrialization caused ravage of vegetation. From extensive literature review it was not possible to get any estimate of vegetation cover and changes occurred to the later in Qatar. None of the publication gave area estimate of vegetation cover in Qatar. All literatures are with some sorts of description of vegetation in Qatar. Although remote sensing technology had been in use since 1983, none of them gone beyond georeferencing and map production from rectified images. None of theses efforts attempted to classification and other analysis of remote sensing data. Such a dent of knowledge regarding vegetation cover in Qatar is the motivation behind this study. This study concentrated to develop a remote sensing and GIS method to estimate desert vegetation in Qatar. For the study Landsat TM image of April 2000 and RADARSAT images were procured. Study revealed that optical remote sensing techniques could effectively be used to assess desert vegetation in Qatar and map them accordingly with a reliable accuracy of 70.67%. RADAR images could not give encouraging results. Poor accuracy might be caused by sparse, less vigor and dwarf type of vegetation.

INTRODUCTION

The Qatar Peninsula is situated halfway along the west coast of the Arabian Gulf, between latitudes 24° 40′ and 26° 10′ north, and longitudes 50° 45′ and 51° 40′ east. It has an area of some 11,347 km², consisting of a peninsula and a number of small offshore islands surrounding it. The Qatar Peninsula lies on the broadest part of the "Arabian Platform" of the Arabian Shelf and is underlain by the basement rocks of the Arabian Shield (Powers, *et al.,* 1966). It projects northward into the Arabian Gulf for about 180 km., while the maximum breadth is 85 km. from east to west. The peninsula is bordered by the Arabian Gulf from west, north and east, whilst beyond its southern limit lies the Kingdom of Saudi Arabia. Like most of the other Gulf States, Qatar has only a small population. The peninsula of Qatar is mostly flat and stony desert, while the desert in the south of the country is sandy. The highest point of Qatar is 83 meters above sea level. Qatar has one of the harshest climates of the Persian Gulf. It is very dry, with an annual rainfall of less than 130 mm/year. Summers are long and hot with high humidity, while winters are pleasantly cool in daytime, but can be freezing in the night. Qatar is strongly urbanized with 90% of the population living in towns and cities. Qatar has a desert climate with temperatures ranging from an average of 23°C in winter to 35°C in summer, when peaks of 49°C have been recorded. The humidity is exceptionally high, often reaching 90% in summer. Total annual rainfall is low and seldom exceeds 75 mm. Most of this rainfall occurs during the winter months, normally in the form of heavy thunderstorms. The prevailing winds are from the northwest and southeast.

Vegetation in Qatar

The extreme climatic conditions in Qatar are not conducive to the development of vegetation. The most widespread soils of Qatar are very shallow (10-30 cm), calcareous sandy loams covered with rock debris and overlying a layer of rock fragments on limestone bedrock. These are of little or no agricultural importance. However, colluvial soils made up of calcareous loam, sandy loam and sandy clay loam have accumulated in a large number of depressions to depths ranging up to 150 cm. These depression soils, which are known as " Rodha", constitute the main agricultural soils of the country. Along the coastal margins, saline soils (Sabkha) occur in extensive playas. Natural vegetation growth in Qatar is limited by the seasonal, erratic and variable rainfall (Batanouny, 1981 and Eccleston *et al.,* 1981). Vegetation and wild life is extremely limited, due to climatic conditions. Only the north has some vegetation. Almost all of Qatar's wetlands are marine and coastal. Around the coast there are extensive coral reefs and sea grass beds, and one notable area of mangroves at Al-Dhakira on the east coast. Only one species of mangrove, the Black Mangrove *Avicennia marina*, is present. Mangrove is also being planted by the Government, but only in small local areas. Parts of the low, rocky coast have broad intertidal flats of sand or mud, but the biological productivity of these appears to be relatively low except in certain spots, mostly on the more sheltered east coast. Extensive Sabkha occurs across the base of the peninsula, and also near Zubarah in the northwest, around Khors on the east and west coast, and around and south of Umm Said in the southeast.

RESEARCH PROBLEM

The State of Qatar utilized remote sensing techniques in various purposes at national and local level. Landsat TM was used to map the Qatar peninsula. However, these works never been attempted to assess vegetation cover in Qatar. The analysis of the above mentioned remotely sensed data were mainly concerned with descriptive illustration of land cover and land use. So far there had been no research on the vegetation assessment using application of remote sensing techniques in the State of Qatar. Therefore this research concentrated to develop a tested and reliable method for assessing the vegetation cover in the State of Qatar using optical Landsat TM data.

RESEARCH OBJECTIVES

Based on above circumstances objective for this study was to develop a tested and reliable method for assessing vegetation cover in the State of Qatar using optical Landsat TM data.

MATERIAL AND METHODS

Study Area

Because of scattered distribution of vegetation fieldwork activities were done in different locations. Locations were purposefully selected to concentrate sample plots in vegetated areas. Field works carried out in the northern part, eastern part of Qatar (Figure 1). Some works were carried out in southern part of Qatar, where some irrigated agricultural practices are done.

Figure 1, Field sample plot locations in northern, northeastern and southern Qatar

Materials used in the research

Optical images of Landsat TM of 27 th April 2000 were used because of their availability and they are the closest dates to the time of time of fieldwork. Beside remote sensing data, other ancillary data such as forest classification maps, information from published unpublished documents of Scientific Applied Research Centre (SARC), Qatar University (QU), and Qatar University Library were also used. Detail description of remote sensing data is given in the Table 1.

Table 1 Detail of optical sensor data used in the study

Sensors	Date of acquisition	Bands (wavelength)	Spatial Resolution
Landsat TM	13 th April, 2000	Band-1 Blue 0.45-0.52 µm Band-2 Green 0.52-0.60 µm Band-3 Red 0.63-0.67 µm Band-4 NIR 0.76-0.90 µm Band-5 MIR 1.55-1.75 µm Band-6 TIR 10.4-12.5 µm Band-7 MIR 2.08-2.35 µm	30 m

Methods

Flow-chart in Figure 2 below shows the image processing and analysis methods applied in the research to attain the research objectives. During fieldwork vegetation were identified with visual observation and located with GPS reading and recorded. As we found from the preliminary classification for fieldwork Wet

Sabkha areas were confusing with class of vegetation, wet Sabkha location and details were also recorded. Vegetation vigor contributes how the image will look like. Again vegetation vigor depends on vegetation composition (which deals with how many species are in the vegetation) and Vegetation structure. Vegetation structure deals with average vegetation height and crown closure percentage. So during field work at each sample plots Species names, vegetation height and crown closure were recorded. The observations from field were used during image classification.

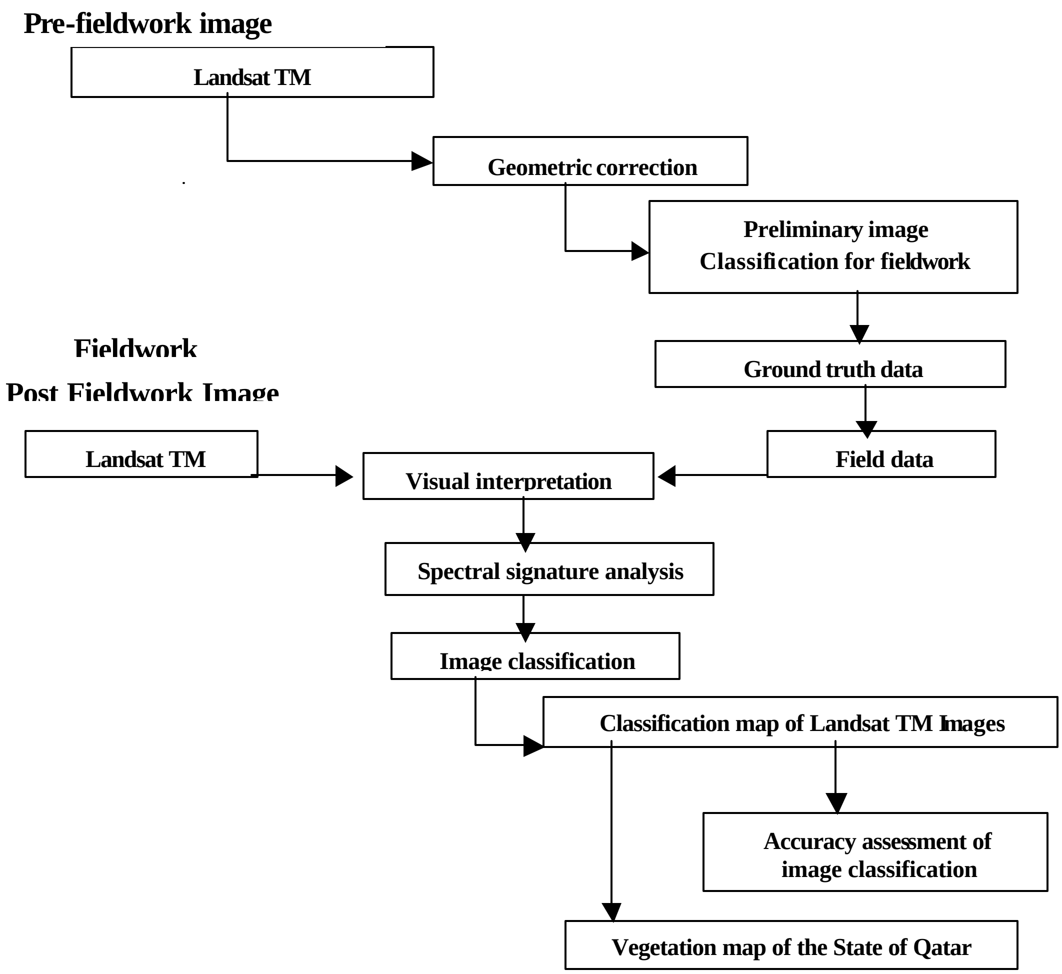

Figure 1 Flowchart of methods applied in the study

Geometric Correction of Landsat TM data

Landsat TM-5 images from April 2000 were collected for this purpose. All the images were subset taking only the international boundary of the State of Qatar. All the three scenes of April 2000 had stripping problem. So, destripping was done using Erdas Imagine 8.4. This brought some amount of smoothing effect on the images. Firstly Mosaic covering the State of Qatar was produced from these three scenes. Then the mosaic georeferenced to Qatar National Grid using Ground Control Points (GCPs) collected from maps of 1:50000 and 1:100000 scales. During georeferencing total RMSE were maintained below 0.30 pixels. All the images were resampled to 30m X 30m pixel size using Nearest Neighbor.

Visual interpretation Landsat TM data

For visual interpretation different colour composites were made with Landsat TM bands 432, 543 and 642 in RGB. Among the colour composites the one 432 showed the best contrast.The scattered desert vegetation found in the field could be seen clearly on the image in light to dark red color. As far as objectives of this research, the colour composite of 432 gave better visualisation and recognition of heavily vegetation area, Sabkha, settlements. In all colour composites clear (e.g., with no forest or tree cover and desert and sand dune background areas appeared as bright features. This was caused by high spectral reflectance on TM band four near infrared (NIR) from. From the contrast between the categories seen on image, vegetation, sand and sand dunes, sabkhas and settlements can easily be separated from each other land cover types.

Classification of remotely sensed data:

Classification can be considered as the process of pattern recognition or identification of the pattern associated with each pixel position in an image in terms of the characteristics of the objects or materials those are present at the corresponding point on the Earth's surface (Mather, 1999). Measured reflection values in an image depend on the local characteristics of the objects on earth surface. The major functions of classification are spatial, spectral and temporal pattern recognition. Although a plethora of image processing methods are available to classify remotely sensed data of desert areas, but finding appropriate one is extremely difficult because unfortunately published reports on accuracy are rare. The lack of accuracy information is by no means unique to remote sensing work on desert vegetation. Rather it appears to feature of remote sensing in the wider resources management context (Green, et al., 1998).

Supervised Classification of remotely sensed data:

When classification is based on specific knowledge of the object features and on the decision rules in the feature space it is called supervised classification. This has been the most frequent method by which remotely sensed data of most areas has been classified (Green, et al 1998). Maximum Likelihood Classification algorithm was used in supervised classification. On the other hand Maximum Likelihood Classifier is the most accurate and efficient classifier. The nature of the desert vegetation here is dwarf type with smaller leaves and less vigor. That means that many field sites with Wet Sabkha will be close to vegetation in spectral reflectance and appearance on image.

Supervised classification was done for the color composite of optical Landsat TM image using all seven bands. Point map produced with plot centre co-ordinates was overlaid on the images. Training sample sets were carefully collected based on the ground truth data gathered during fieldwork. During collection of sample sets on image the position of clusters and class statistics were carefully verified through the performance of cluster diagram in feature space. This enabled to judge whether different classes could really be spectrally separated and each class corresponds to only one spectral cluster. Extra care was ensured in taking samples in the class of vegetation and Wet Sabkha. In the sample statistics mean and standard deviations for different bands were maintained within a certain range as well as maximum value for each band. At the same time training samples were also observed on the images, if pixels of different colours representing different classes were included. In such cases all pixels from other class/es then the class of interest were selected and deleted individually with mouse action. This was done to ensure inclusion of pixels with only similar values for the same class.

Following the completion of training sample set collection classification was run on mosaic. Maximum likely hood classifier in parametric rule was applied in ERADS IMAGINE. "The maximum likelihood decision rule in is based on the probability that a pixel belongs to a particular class. The basic equation assumes that these probabilities are equal for all classes, and that the input bands have normal distributions" (ERADS, 1999). From the field knowledge it was clear that vegetations height is low (not exceeding 5 meters) and foliage is also low. Leaves were found to be of light green to grayish green. Based on field knowledge following six classes:

♣ Shallow Water

As Qatar peninsula is projection in the Arabian Gulf it almost surrounded by coast. Along its coast shallow but clear water is a permanent feature. Water is intruding into

♣ Wet Sabkha

Parts of the low, rocky coast have broad intertidal flats of sand or mud, but the biological productivity of these appears to be relatively low except in certain spots, mostly on the more sheltered east coast. Extensive Sabkha occurs across the base of the peninsula, and also near Zubarah in the northwest, around Khors on the east and west coast, and around and south of Umm Said in the southeast.

♣ Mangroves

Almost all of Qatar's wetlands are marine and coastal. One notable area of mangroves is located at Al-Dhakira on the east coast. Only one species of mangrove, the Black Mangrove *Avicennia marina*, is present♣Vegetation

The extreme climatic conditions in Qatar are not conducive to the development of vegetation. Only the north has some vegetation.

♣Deep Water

This class of Deep Water was included to separate seawater from shallow water along the coast.
♣Others
It includes all other features those were not included in the above mentioned classes. Mainly settlements, infrastructures, sand dunes and deserts were included in this class.

Accuracy assessment
During fieldwork two sample sets were collected. One training sample set was for supervised classification of image and the other ones were test sample set for accuracy assessment of classification. Following the classification confusion matrix was generated in Erdas Imagine.

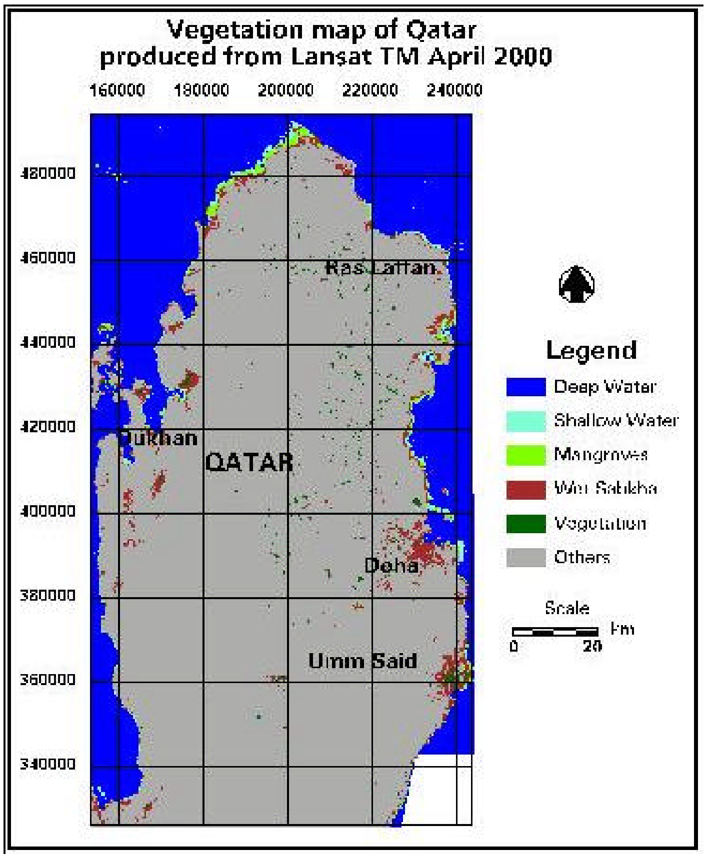

Figure 3 Classification map of Landsat TM image of April 2000

RESULTS AND DISCUSSION
Supervised classification of Landsat TM image

Qualitative evaluation of supervised classification of Landsat TM image
From the supervised classification (Figure 2) of Landsat-TM data nine classes can be well identified. The classes are Shallow Water, Wet Sabkha, Mangrove, Vegetation, Deep Water and Others. Resolution of Landsat TM data is 30 m x 30 m. However, taking into account the complexities of the spectral separation between the classes have led to limit the classification to six land cover classes mentioned earlier. Moreover, when more classes with different vegetation and land cover types were included in the classification the results were confusing. Most of the classes were mixing with each other. It can be explained that the classes and subclasses seen in the field cannot be detected or classified spectrally from the image. This may be attributed by dwarf type scattered and less vigorous vegetation with small leaves. Most vegetation found with an average height between 2 m to 5 m. It is clear from Figure 3 that the signature of "vegetation" spectral class has moderate standard deviations or variance. Consequently, many cluster of pixels showed in the class of vegetation appeared scattered throughout the classification map of Landsat TM image (Figure 3). In some cases vegetation class is so distributed that Wet Sabkha is within the class of vegetation. This can be attributed to the similar moisture content of vegetation and grassy population in the Wet Sabkha.

Quantitative evaluation of supervised classification of Landsat TM image

Overall classification accuracy of 76.42% of Landsat TM image (Table 2) could be achieved. From the overall classification accuracy, it can be stated that classification had been reasonably good. However, accuracy per class was 70.67% for the class of vegetation. On the other hand minimum accuracy of 69.39% found in case of mangrove class. The area coverage of the class vegetation is 9564 ha with 106267 pixels. This moderate accuracy in detecting vegetation can be attributed to the field conditions of low vegetation vigor, low foliage and low density of vegetation. Because of these factors spectral reflectance from vegetation tended to share with the wet Sabkha and some sandy desert.

Table 2. Confusion matrix generated for accuracy assessment of classification of Landsat TM image, April 27, 2000

Classes	**Wet Sabkha**	**Shallow Water**	**Mangroves**	**Vegetation**	**Deep Water**	**Others**	**Row total**
Wet Sabkha	**67**	6	9	11	0	3	96
Shallow Water	5	**65**	5	2	3	4	84
Mangroves	9	2	**68**	7	1	6	93
Vegetation	7	3	10	**53**	0	8	81
Deep Water	4	8	2	0	**79**	1	94
Others	3	0	4	2	0	**73**	82
Colunm total	95	84	98	75	83	95	**530**
Reliability	70.52631579	77.38095238	69.3877551	**70.66666667**	95.18072289	76.84210526	
Overall accuracy							**76.415094**

CONCLUSION

From the study it is revealed that desert vegetation in the State of Qatar can be assessed and mapped using Landsat TM image. For better result with higher accuracy other sensors with higher spectral and spatial resolution can be studied. Even data fusion can also be tried to better detect desert vegetation.

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