Ground surface conditions of oases surrounding the Taklimakan Desert

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Abstract

The analysis of images taken around the Taklimakan desert Desert with a camera onboard CORONA during the 1960's and with multispectral sensors, ASTER and, MODIS onboard TERRA in 2000 indicated a number of features. Specifically, oases on the southern edge of the desert have more potential as farmland than those on the northern edge based on the ratio of both NDVI and high-density NDVI (HD NDVI) derived from MODIS data. Furthermore, the total vegetation area around the boundaries of large oases has increased, indicating increases in farmlands and forest areas during the last 40 years. An in situ survey revealed that a great efforts have has been continued made since the end of 1950 to increase forests to protect against the invasion of desert sand and also to increase farmlands. Irrigation canals and reservoirs for supplying farmlands with the water were also built during this period.

Introduction

The most fundamental and important approach to investigating the mechanism of recent desertification is to extract the time-series variation of the ground state, find the relationship between the variation of the ground state and the various factors likely to be related to desertification, such as climate and human activities. Until now, however, very little data concerning the ground state in arid and semi-arid lands has been available because of the difficulty of collecting data from vast areas under severe weathers conditions.

The remote sensing data collected from the satellite contain much useful information on ground states. Furthermore, remote sensing techniques can collect the data from vast areas instantaneously and repeatedly. In addition to these excellent capabilities, previously gathered data has been accumulated.

For example, the camera onboard CORONA collected data over the Taklimakan desert in China during the 1960s was collected. In addition to this older data, data acquired by new satellite sensors such as the multispectral sensors, ASTER and, MODIS onboard TERRA are now available. Accordingly, it is now possible to compare the old satellite data with the new data in order to extract time-series variations of the ground state over a vast area.

We investigated the land use around oases along the southern and northern edges of the Taklimakan desert. In this paper, we report on the present ground state of the oases using the data of the MODIS onboard TERRA. We then investigate the variation of ground states in the oases of Pishn and Hotan located on the southern edge of the Taklimakan desert based on the data acquired from CORONA in the 1960's and ASTER in 2001.

Results and Discussion

Present Ground State of Oases Surrounding the Taklimakan Desert

By calculating the ratio of both NDVI(0.4-0.9) and HD NDVI(0.6-0.9) derived from MODIS data is shown Fig. 1, it is possible to estimate the potential and scales of irrigation farmland. Figure. 2 illustrates the relationship between

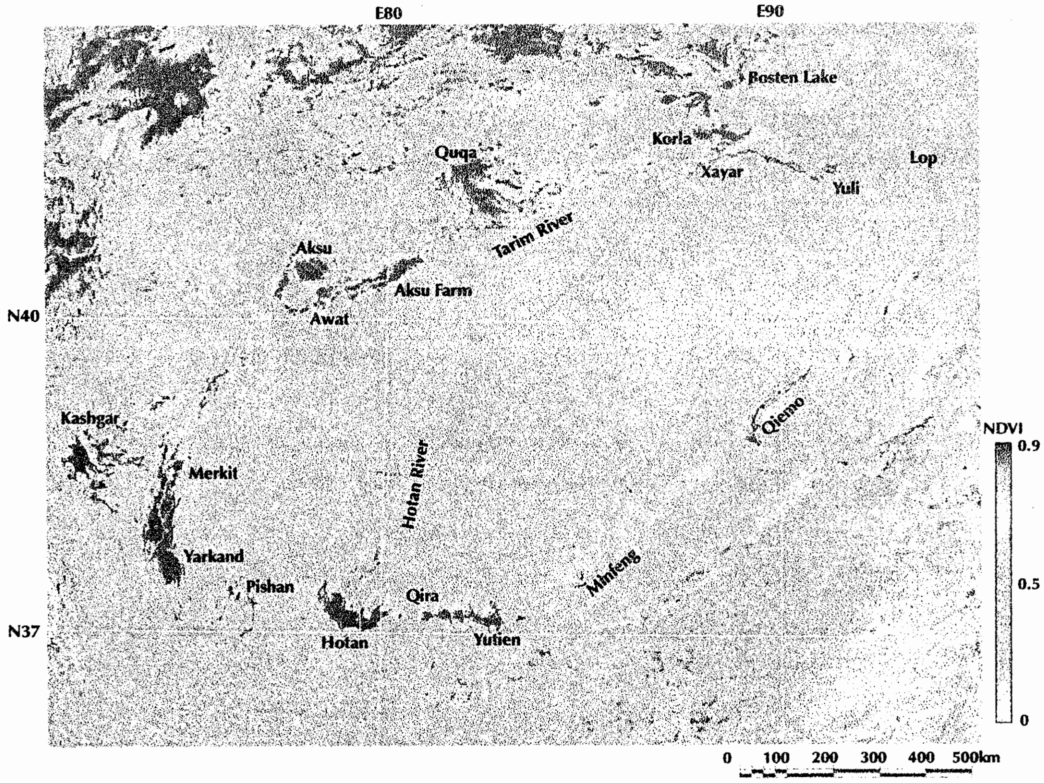

Fig. 1. Distribution of vegetation index around Tarim basin derived from geo-coded MODIS data on July 29th 2000.

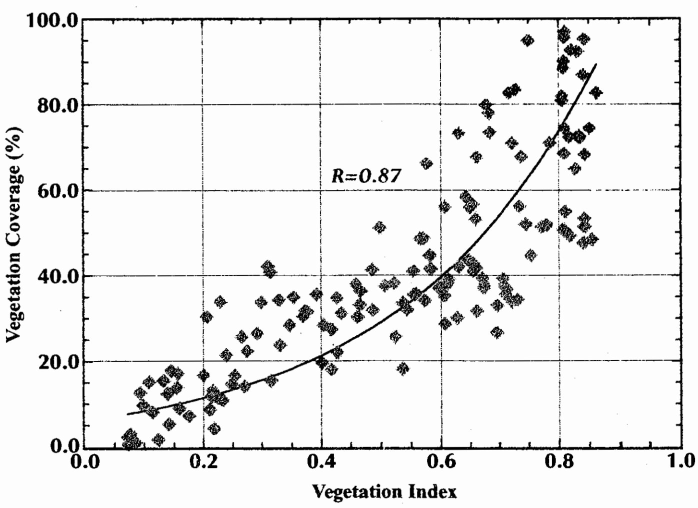

Fig. 2. MODIS NDVI as shown in Figure 1 vs vegetation coverage.

MODIS NDVI shown in Fig. 1 and vegetation coverage derived from in situ measurement. Fig. 3 depicts the in situ measurement of the vegetation cover based on the method of a 100m cross a length of vegetation laid out in two 100m orthogonal lines. The results suggest a greater potential as farmland for the oases on the southern edge of the Taklimakan desert than on the northern edge.

There are many extensive oases over 1500 square kilometers in area on the northern edge of the Taklimakan desert, and the ratio of NDVI to HD NDVI exceeds 0.3 as shown in Table 1. This means that the utilization as irrigated farmland is high, and these oases are dependent on the quantity of water of the large tributaries flowing into the Tarim River. The Tarim River originates in glacier and snow fields in the mountains and was formed by three tributaries, the Hotan River (supplies 22% of the water), the Yarkand River (supplies 6%), and the Aksu River (supplies 72%) is shown in Fig. 4. Therefore, the volume of river water from the Tianshan mountain range enables the existence of formation of larger oases on the northern edge of the Taklimakan desert than on the southern edge. [1]. Generally, small oases are more abundant on the southern edge, and the ratio of NDVI to HD NDVI is 0.15, so there are large areas of unutilizable grounds around the oases. The utilization factor as farmland obviously depends on the quantity of the irrigation water.

Fig. 3 In situ measurement of the vegetation cover based on the method of 100m cross (length of the vegetation in orthogonal 100m lines).

Therefore, on the northern edge, the quantity of river water of from the Tianshan mountain range enables the formation of large oases. On the southern edge, there is only a small amount of meltwater from the mountain range, and the river channel is long and segmented. This quantity of water is the main reason and that the oases are small, and have a low land utilization factor. The vegetation area around the Taklimakan desert is about 23,000 square kilometers (derived from MODIS NDVI), which is about ten times the area of Metropolitan Tokyo, Japan.

This area presently faces the threat of desertification. The areas of the Taklimakan desert as derived from MODIS data, is 303,834 square kilometers. The literatures gives an area of 270,000 square kilometers (New Encyclopedia Britannica) and 320,000 square kilometers. The total area of the oases is less than the area of the Taklimakan desert. As a result, the vegetation area in the oases does not seem to contribute to controlling dust storms.

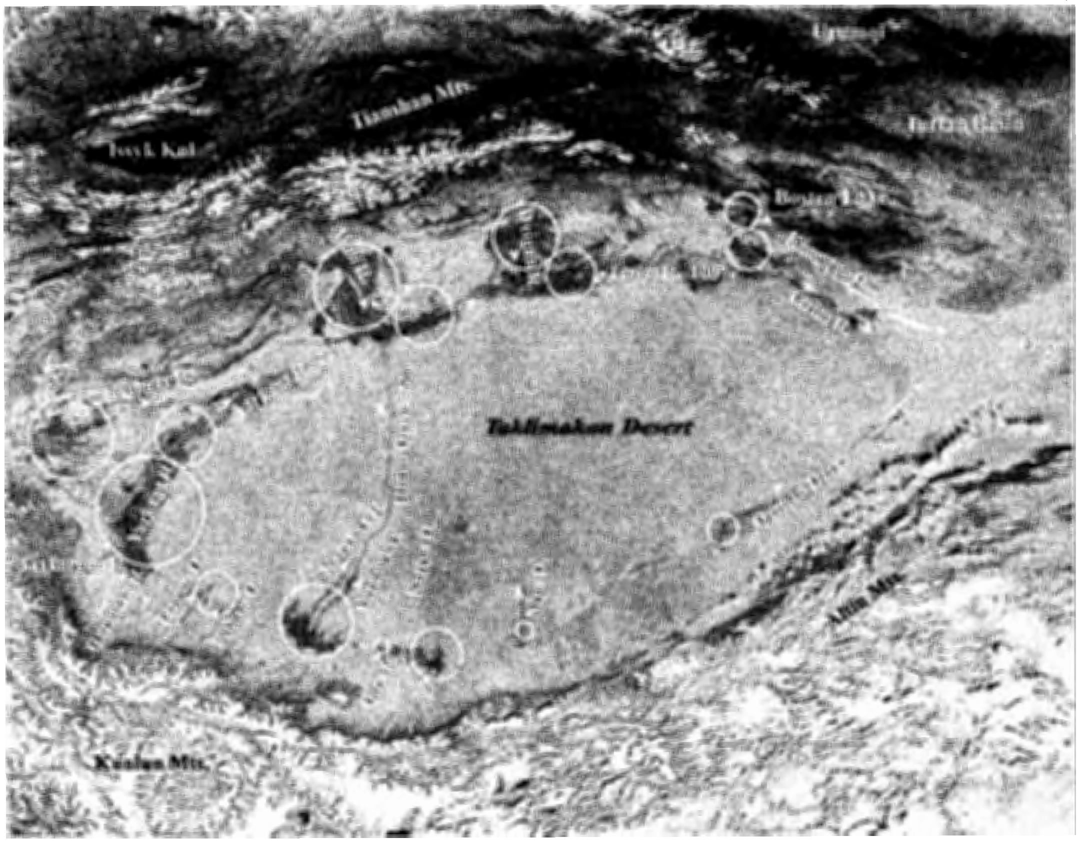

Fig. 4. MODIS true-color image around the Tarim basin. The circles indicate various area oases surrounding the Taklimakan Desert. The blue shows the lakes and reservoirs. The arrows show the drainage patterns (October 7, 2001).

Extraction of Desertification Areas

The change of surface conditions around the southern edge is complicated [2,3,4]. The land cover change of Pishan and Hotan oases can be estimated from the CORONA data acquired from early 1960 and data acquired by ASTER from2000. Prior to comparing the 1960 CORONA images with the 2001 ASTER images, geometrical correction (affine transformation) is necessary. CORONA imagery from 1960 was co-registered with ASTER data from 2001 by comparing the positions of the same point in two images. Figure 5 shows the color image composed of a reverse image of the panchromatic CORONA image in red and reverse images of ASTER band 1 in both green and blue prepared to extract land cover changes, particularly vegetation features during this period in Pishan. The result shows that reservoir and irrigation canals were constructed recently in these oases which develop in the alluvial fan, and that there is an expansion of the farmland around oases. At the same time, however, here is declining vegetation in the downstream area due to water shortages. Though irrigation for Pishan oasis depends on small rivers and ground water, the extension of farmland is difficult, since the quantity of water is very small. There is a small reservoir, but the irrigation water is not distributed sufficiently in the downstream area, and the extending farmland is difficult. During the last 40 years the desert areas obviously extended towards the inner oasis. In particular, the land degradation crisis progresses because of the invasion of the desert sand in the circumference in the oases. In addition, the Hotan oasis was formed from two large rivers, and the oasis also forms some large reservoirs, and contributes to the extension of farmland. Table 2 indicates the land cover change in Pishan and Hotan oases from 1960 to 2000 as derived from CORONA and ASTER data. In this region, the water control system does not function, and water is not being fairly allocated at present. This further contributes to the suppression of agriculture in the lower current area and land degradation downstream. Appropriate water resource management will thus be significant in the success or failure of efforts to prevent desertification of forestland around the oases.

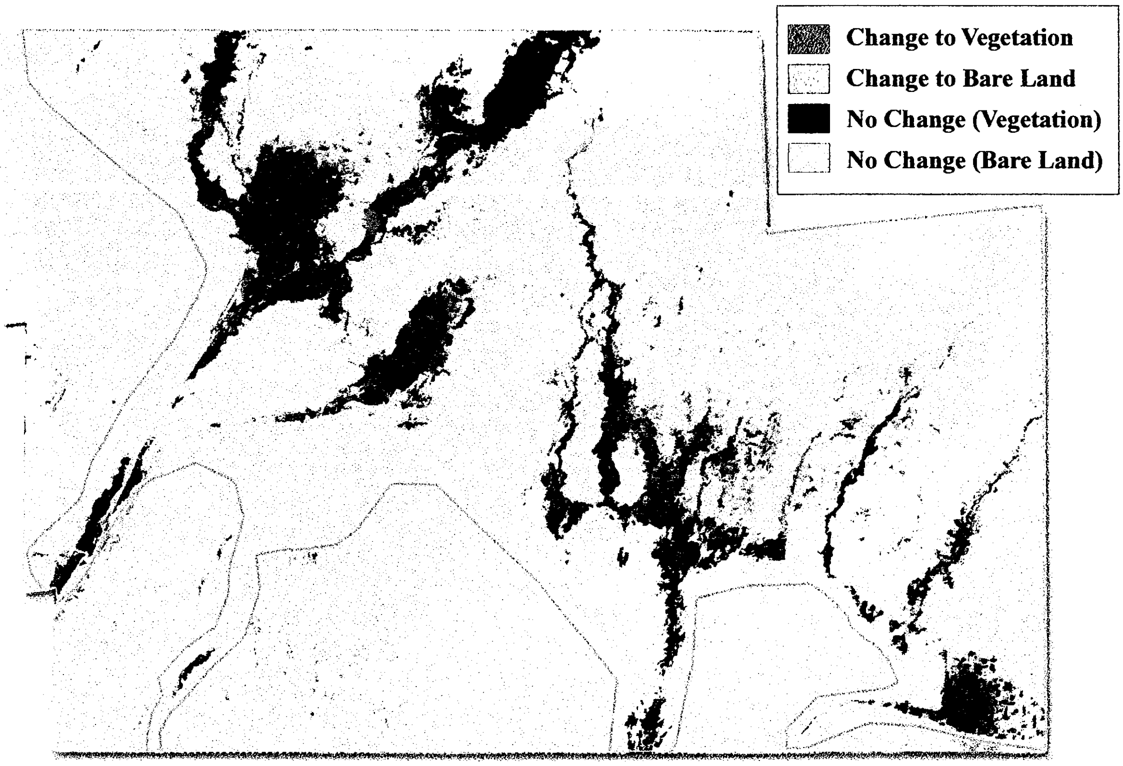

Fig. 5. Land cover change in the Pishan area between 1960 and 2000, derived from CORONA and ASTER images.

Thus, the comparison between the imagery obtained in the 1960's and 2001 suggests that large scale desertification has continued for 40 yeas but has been increased as a results of irrigation and forestation. Accordingly, a possible decrease in the vegetation in the desert areas located downstream may be detected by comparing data from CORONA with data from new satellite sensors such as ASTER and, Landsat ETM. The images of the downstream area should be compared to further investigate the effect of water consumption due to irrigation in the upstream area upon the vegetation in the down stream area.

Table 1. The areas of the oases around the Tarim Basin derived from MODIS NDVI and its ratio.

Oasis	NDVI (0.4-0.9)	HD NDVI (0.6-0.9)	Ratio of NDVI (0.6-0.9)/(0.4-0.9)
(Northern Edge)			
Aksu	1,406.9	438.4	0.31
Aksu Farm	1,423.4	549.0	0.39
Awat	709.9	48.2	0.07
Quqa	1,934.7	267.9	0.14
Xayar	2,178.7	109.6	0.05
Yuli	1,539.9	260.1	0.17
Korla	843.3	340.6	0.40
(Western Part)			
Yarkand	3,290.7	1,277.4	0.40
Merkit	1,242.9	108.0	0.09
Kashgar	3,017.8	670.9	0.22
(Southern Edge)			
Qiemo	846.5	97.6	0.12
Minfeng	193.4	3.0	0.02
Yutien	1,060.2	125.5	0.12
Qira	421.4	68.7	0.16
Hotan	2,464.9	365.9	0.15
Pishan	296.9	41.9	0.14
Total	22,871.2 km^2	5,082.8 km^2	

Table 2. Land cover change in Pishan and Hotan oases during 1960 and 2000, derived from CORONA and ASTER data.

	Pishan	Hotan
Change to Vegetation from Bare Land	75.0	441.8
Change to Bare Land from Vegetation	106.9	195.0
No Change (Vegetation)	161.5	157.3
No Change (Bare Land)	1680.3	1814.1

(km^2)

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