Effect of Water Allocation on Vegetation Variation of Ejina Oasis in Heihe River Basin

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Abstract. The vegetation dynamic of the Ejina oasis before and after the water allocation in the lower reach of Heihe River Basin were analyzed using Landsat data. The impact of the water allocation on vegetation changes in Ejina oasis was remarkable. Vegetation NDVI of Ejina was relatively stable from 2000 to 2004 and increased from year to year since 2005. Vegetation distributed along the river and around the Ejina County. The most notable spatial changes of vegetation NDVI happened neighboring East Juyan Lake. The remarkable changes in vegetation improvement was shrub from 2000 to 2010.

Introduction

Ejina oasis in Heihe River Basin is a typical desert oasis of northwest arid areas in China. The upstream water of Heihe River is alone water source that maintains Ejina oasis [1]. As a result of the middle reaches of Heihe River over-development and over utilize water resource, taking the land desertification, the vegetation degenerates as representative's ecological environment worsen has affected seriously the downstream desert oasis and restricts economy of river basin and society's sustainable development.

Ejina ecological environment had been worsened since the 1990s, it includes the blocking the flow, the terminal lake vanished, the lowering of groundwater table, the vegetation degeneration, the natural oasis withering, the land desertification rapid development, the sand storm aggravating harm. It not only had caused the region environment to worsen and the biological species reduction, but also has threatened ecological security and the environment condition in the entire river basin.

Water allocation of the Heihe River (WAHR), initiated in 2000, was a significant ecological restoration project. The focus of the WAHR was on allocation of water resource to downstream, though adjusting of plant structure, water save and conceding the land in the middle stream [2]. To understand the effect of the WAHR on vegetation variation in the Ejina oasis, vegetation NDVI and land cover were investigated for this study. The primary objectives is to use remote sensing data to analyze the dynamic vegetation variation before and after the WAHR.

Materials and Methods

Study Area

The Ejina is located between 99°03′~100°00′E, 40°30′~42°30′W, is a large alluvial fan of the termination which locates at the catchment area of Heihe River. It is in the most western of Nei Mongolia autonomous region, the total area is 114.6 thousand km². Ejina is an animal husbandry
border county where the Mongolia Race of Torguttribal descendant is main part. Total population only 15.7 thousand, among of which agro-animal husbandry population is 3.5 thousand. Ejina oasis is located flat basin in the middle of Ejina. Annual average temperature is 8.3°C, and yearly average rainfall is 30~50mm, the yearly average evaporation is over 3000mm.

Data Sources

NASA’s Landsat Program-Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM) was used to ground feature identification and information extraction, and were suitable for monitoring vegetation coverage changes. In order to monitor the effect of the water supplement on vegetation coverage using multi-temporal satellite images, the TM and ETM data covering the entire study area
in Ejina oasis were acquired on 2000 and 2010. The images were taken when vegetation was growing well and could fully represent the growing conditions of the vegetation in the study area.

NDVI, which reflects characteristics of plant growth and vegetation coverage [3], was used as an indicator of the spatial distribution of plant growth and vegetation density [4]. The spectral reflectance values are themselves ratios of reflected over incoming radiation in each individual spectral band, hence they take on values between 0.0 and 1.0. NDVI itself thus varies between -1.0 and +1.0 by design [5]. MODIS NDVI data set were produced on 16-day intervals and at multiple spatial resolutions, provide consistent spatial and temporal comparisons of vegetation canopy greenness, which provides continuity with NOAA's AVHRR NDVI time series record for historical and climate applications. MODIS NDVI data of 1km pixels covering the entire study area were acquired from 2000 to 2010.

Data Processing

Remote sensing data process and analysis were performed using ArcGIS 10.0 and ENVI 4.4 image processing software. The original TM and ETM images were georeferenced to the Universal Transverse Mercator (UTM) projection system by the nearest-neighbor resampling method. To normalize the coordinate system, a geometric correction was carried out for the TM and ETM image based on the 1:50,000 digitized map.

The land covers were grouped into nine types according to the characteristics of spectral reflectance and the objectives of analysis: high coverage forest, moderate coverage forest, low coverage forest, high coverage shrub, moderate coverage shrub, high coverage grassland, moderate coverage grassland, cropland, and unutilized land by using supervised classification and visual interpretation. The accuracies of the classified products were assessed by using Google Earth Pro® (GE), which is a practical means to validate land cover classification results. Based on the classified products, the land cover changes from 2000 to 2010 was analyzed. MODIS NDVI data were performed several pre-processing steps, include mosaic, reprojection and resize by MODIS tool.

Results

Temporal and Spatial Variation Trends of NDVI

Fig. 2 shows temporal variation trends of NDVI in Ejina oasis from 2000 to 2010. Vegetation NDVI was relatively stable from 2000 to 2004. Vegetation NDVI increased from year to year since 2005, because of water dispatching mode from emergency dispatch changed to regular dispatch, scheduling time changed from half year to annual.

Fig. 3 shows the spatial distribution of NDVI in 2000, prior to the WAHR, and after its implementation in 2010. Spatial distribution of NDVI in Ejina oasis (Fig. 3) showed that vegetation distributed along the river and around the Ejina County. Relatively higher NDVI was observed in the northern parts of the study region. The higher NDVI distributed mainly around the water, while lower NDVI was located in the Gobi and desert, as would be expected. The most notable spatial changes of vegetation NDVI happened neighboring East Juyan Lake.

Vegetation Variation from 2000 to 2010

Vegetation variation for 2000 and 2010 are shown in Table 1. According to the table, moderate coverage grassland, moderate coverage shrub, and high coverage grassland were the three largest vegetation types in the region from 2000 to 2010. Grassland constituted 62.4%, and 58.8% of the total vegetation area, shrub constituted 24.7% and 27.1% of the total vegetation area in 2000 and 2010, respectively. Areas of cropland, high coverage shrub, moderate coverage shrub, and moderate coverage forest increased from 2000 to 2010. On the contrary, areas of high coverage grassland, low coverage forest, high coverage forest, and moderate coverage grassland decreased. Cropland grew most rapidly and high coverage grassland reduced at the fastest rate. The remarkable changes in vegetation was an improvement in shrub from 2000 to 2010.
Figure 2. Temporal variation trends of NDVI in Ejina oasis from 2000 to 2010.

Figure 3. Spatial distribution of NDVI in Ejina oasis for 2000 and 2010.
Table 1. Vegetation variation for 2000 and 2010.

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (km²)</th>
<th>Comparison for 2000 and 2010</th>
<th>Net change (km²)</th>
<th>Change ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High coverage forest</td>
<td>129.81</td>
<td>124.06</td>
<td>-5.75</td>
<td>-4.4%</td>
</tr>
<tr>
<td>Moderate coverage forest</td>
<td>155.65</td>
<td>155.80</td>
<td>0.15</td>
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</tr>
<tr>
<td>Low coverage forest</td>
<td>104.90</td>
<td>94.35</td>
<td>-10.55</td>
<td>-10.1%</td>
</tr>
<tr>
<td>High coverage shrub</td>
<td>251.07</td>
<td>314.32</td>
<td>63.25</td>
<td>25.2%</td>
</tr>
<tr>
<td>Moderate coverage shrub</td>
<td>570.46</td>
<td>614.55</td>
<td>44.09</td>
<td>7.7%</td>
</tr>
<tr>
<td>High coverage grassland</td>
<td>492.98</td>
<td>440.92</td>
<td>-52.06</td>
<td>-10.6%</td>
</tr>
<tr>
<td>Moderate coverage grassland</td>
<td>1585.20</td>
<td>1573.89</td>
<td>-11.31</td>
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</tr>
<tr>
<td>Cropland</td>
<td>38.38</td>
<td>110.54</td>
<td>72.16</td>
<td>188.0%</td>
</tr>
<tr>
<td>Amount</td>
<td>3328.46</td>
<td>3428.42</td>
<td>99.96</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

Summary

Vegetation variation of Ejina oasis before and after the water allocation of the Heihe River were analyzed using Landsat data. The impact of the water allocation on vegetation changes in Ejina oasis was remarkable. Vegetation NDVI of Ejina was relatively stable from 2000 to 2004 and increased from year to year since 2005. Vegetation distributed along the river and around the Ejina County. The most notable spatial changes of vegetation NDVI happened neighboring East Juyan Lake. The remarkable changes in vegetation improvement was shrub from 2000 to 2010.

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References