# Land use/cover change dynamics of the Heihe River basin revealed by knowledge-based classification with Landsat TM, DEM and other information *

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**Abstract** Radiometric correction was difficult to perform on imageries of mountainous areas where atmospheric and climatic data were difficult to obtain, because of the absence of weather station. It was a general knowledge that the classification of the non-radiometrically corrected imagery resulted to misclassifications, low accuracy and inconsistencies. From these problems, the objective of this study were drawn, namely to utilize a knowledge-based decision land cover and land use data. The study site was the heihe watershed, Province of Gansu, China. Two sets of Landsat TM taken form 1989 and 2002 were used as inputs to the project. The raw imageries were geometrically rectified, and atmospheric correction was done by the software of 6S. classified image using knowledge-based decision rule criteria created by the software of ERDAS Imagine. Result of the cross-tabulation showed that the classified imageries refined by the computer program had no incidence of invalid change result unlike the classified imageries produced without the assistance of the knowledge-based computer program. Also, its classification accuracy was higher than that of the imageries produced without the assistance of the computer program. We therefore conclude that the use of knowledge-based decision rule computer program to assist the standard classification procedures improved the accuracy of the land cover and land use data and the consistency of the land cover and land use change results.

**Key words:** land cover and land use change, knowledge-based rule criteria,

## 1 Introduction

Land cover/use change (LCLUC) is an important ecological factors reasoned from Landsat Thematic Mapper. Resource management can be effectively implemented if the resource manager has an idea of the rate at which land cover/use changes over time and what land uses are dominating and which ones are decreasing. Land cover/use change analysis is done using time series analysis of imageries of an area taken at different dates. Data that are ideal for time series analysis are data taken at the same date of different years. Many studies developed kinds of methodology to obtain more precision land cover result. Usually statistical approaches such as maximum likelihood are used to classify the data into different land cove classes, which are associated with the land being severely affected, slightly affected and not affected.

The above approaches provide a means of monitoring the extent of land cover/use classes, but provide no dominate species. To explore ways of achieving these aims, we developed a knowledge-based system for representing relationships relevant to dominate species distribution factors such as elevation, soil type, and soil moisture and so on. This knowledge-based decision rule criteria takes various input map in a GIS and applies rules, which have varying degrees of confidence, to produce output maps of exiting land cover/use types.

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## 2 Study area

Study area constitutes a part of Heihe watershed, located in the west-north of China and covers about 300 $km^2$ (Fig 1). The central part is Zhangye city, which is developing city depend on agriculture. The climate is typically temperate aridity and semi-aridity region.

Fig.1. The sketch map of Heihe river basin

This area has a wide variety of land cover/use features such as forest land, sub-alpine shrub, sub-alpine meadow, agricultural land, rangeland, built-up lands, water bodies, low wet land and open or barren lands. Their main domain species include *stipa purperea, Stipa krylovii, Elymus nutans, Kobresia capillifolia, Kobresia humilis, Potentilla fruiticosa, Salix cupularis* (Table 1). Ground truth data were collected in August 2002 in the study area. Prior to classification and integration analyses, processing to correct for systematic geometric distortion characteristic of each image has been carried out. Canal bends and road intersections are found to be the best GCPs and image were done geometric correction by using ERDAS of remote sensing software. For decade landcover and landuse changed quickly, As Zhangye city expand. So it is very important what is the main drive for land cover/use change, and how to arrange landuse. In this paper, we will answer these questions.

**Table 1 Main features of land cover/use type in Heihe river basin**

| Land ocver/use type | Features | | |
|---|---|---|---|
| | Soil type | Domain species | Company species |
| Sub-Alpine shrub meadow | meadow soil | *Salix cupulais* *Pottentilla fruticosa* | *Elymus nutans, Ptilagrostis dichotoma, Poa pratensis* |
| Alpine meadow | Meadow soil | *Kobresia pymaea* | *Astragalus polycladus, Gentiana macrophylla* |
| Steppe | Chestnut soil | *Stipa purpurea* *S. purpurea* | *Anaphalis lacteal, Bupleurum sp , Stellera chamaejasme* |
| Desert steppe | slight chestnut soil | *Ceratoides lateens* *Auania sp* | *Poaalpina, Carex moorcroftii, Astragalus sp , Pottentilla multifida* |
| Marshland | Marsh soil | *Blymus sinocompressus* *Pottentilla anserine* | *Carex scabrirostrix, Triglochin maritimum* |
| Agriculture | Slight chestnut soil | Maize | No |

## 3 Material and Methodology

### 3.1 Material

Two periods Landsat thematic mapper data are used for this research. One obtained on June 9, 1989, another is on July 31, 2002. Digital elevation model (DEM) is built use GIS software of

ArcGIS 8.1. Its scale is 1: 50,000 and pixels size is 30 plus 30 meter. Otherwise digital soil map, rivers net map, lake map, and field investigation data are used for land cove classification. And More than 50 samples were collected in this basin.

Landsat thematic mapper was geometric correction by the software of ERDAS Imagine®. And atmospheric correction was processed by the software of 6S. The result was verified by field experiment.

**3.2 Methodology**

In this research, topographical normalization was first performed to remove the effects on spectral reflectance introduced by differential illumination and shadowing caused by terrain variability. Secondly, corrections were applied to account for brightness differences caused by different atmospheric conditions, moisture, and sun angles between the two dates. Then, a knowledge based approach was developed to reduce the cloud and shadow using two images of different dates. In this paper, the main image refers to the principal image to be used in subsequent analysis, such as land cover classification, and which possesses less cloud and shadow area than the secondary image, used to supplement the values for cloud and shadow areas the main image. The idea is to detect those areas which are covered with cloud and shadow in the main image, and not having cloud or shadow in the secondary image. This is accomplish using a combination of spectral information and shape features. Finally, the spectral values of cloud and shadow areas in the main image were replaced with those from cloud-free and shadow free areas in the secondary images.

In this paper put forward a kind of methodology is based on the geographical knowledge classification. This methodology is developed by the basic of supervise classification. Mainly idea as follow(Fig.2):

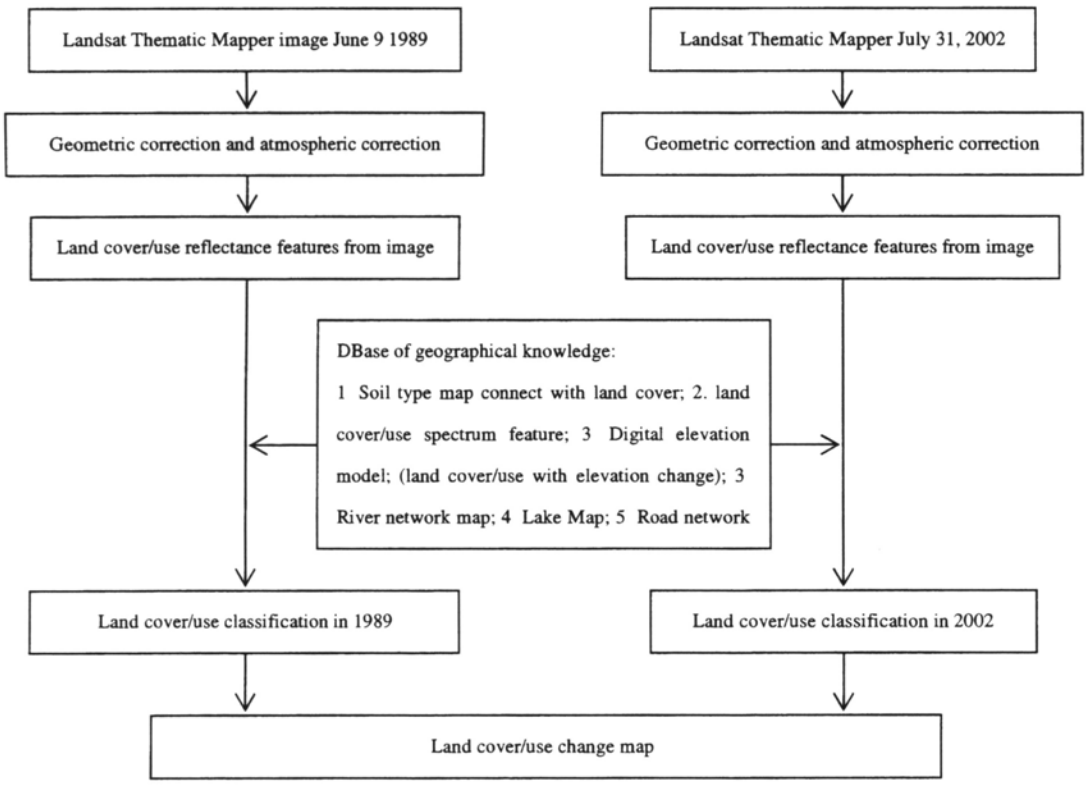


Fig 2 The workflow of classification based on geographical knowledge

According to our methodology, the key of processing procedure as follow:

**Create Dbase of geographical knowledge**

Unless the different land cover/use is relational with features of land cover/use spectrum, other factors effect its distribution change such as elevation, aspects, soil type and so on. So there are very important for use geographical knowledge data supporting land cover/use type classified.

**(1) Topographical analysis**

As previously stated, the high altitude of the Heihe river basin makes it rather cold throughout the year, and more precipitation. So there are different land cover/use distributions in the different high zone, which is called distribution law of zone. Also the different slope, aspects effect the distribution of land cover/use. So the result of topographical analysis is very important knowledge to classify land cover/use types.

In this research, we collect topographical map which scale is 1: 50000. From this data we use the software ArcGIS to create the DEM, which pixel size is 30 meter. And then to create slope and aspect from DEM data.

**(2) Other knowledge**

The materials used in this study include topographic maps of 1:500000 scales, a map of land use types, and *in situ* collected grass samples whose positions were determined with a GPS receiver.

**(3) Spectrum features analysis**

The aim of this research is modification classification method to improve the result precision. Spectrum feature analysis is very important to dig the land cover/use type knowledge of spectrum. All spectrum knowledge of land cover/use were measured by FieldSpec® Pro made by USA. Analytical Spectral Device, Inc.. Spectrum wide is from 0.4 to 1.0,,m. Main typical land cover/use spectrum features are shown by fig.3:

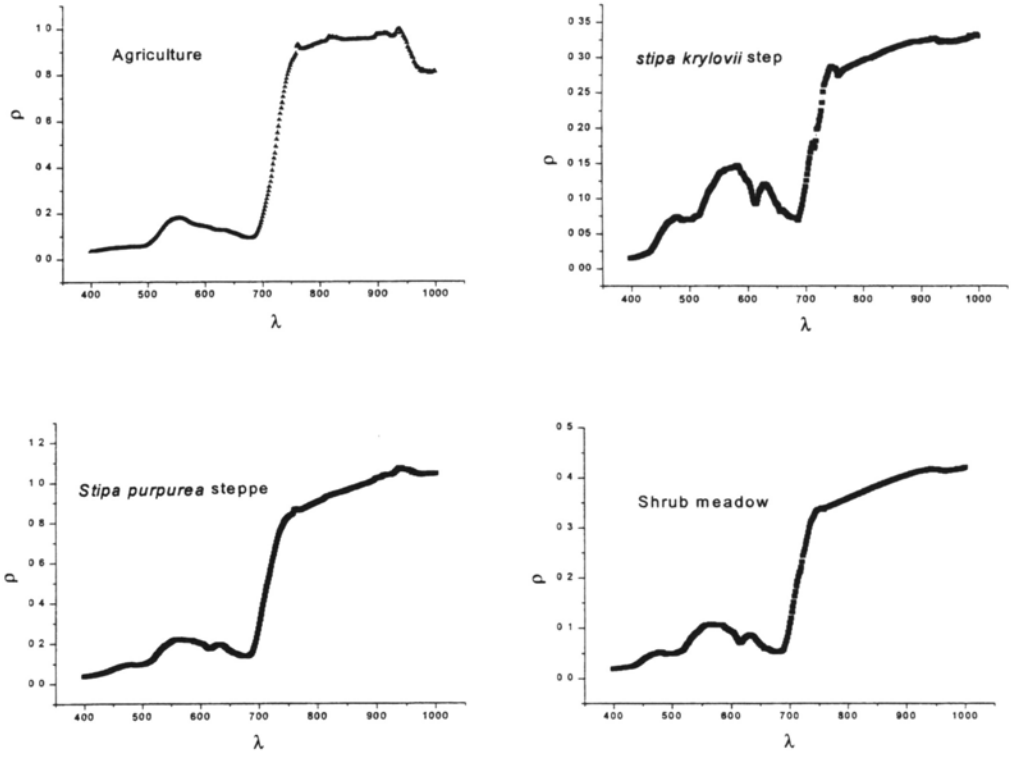


fig 3 The spectrum feature of typical land cover/use

From these spectrum data

**Create knowledge-based decision rule criteria**

It is very important to Create a truth knowledge-based decision rule criteria. In this paper, decision rule criteria were created by the software of ERDAS imagine (Figure 4). Knowledge root in field spectrum measured data analysis, DEM, and other data.

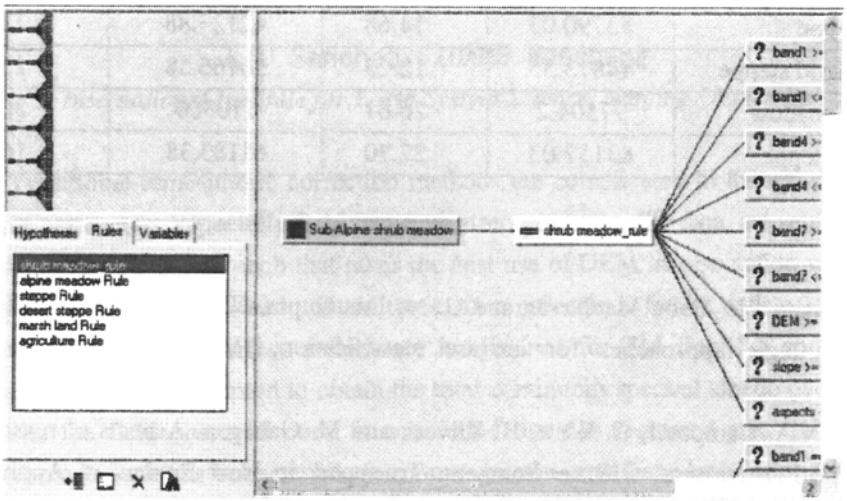


Fig 4 The process of knowledge-base classification

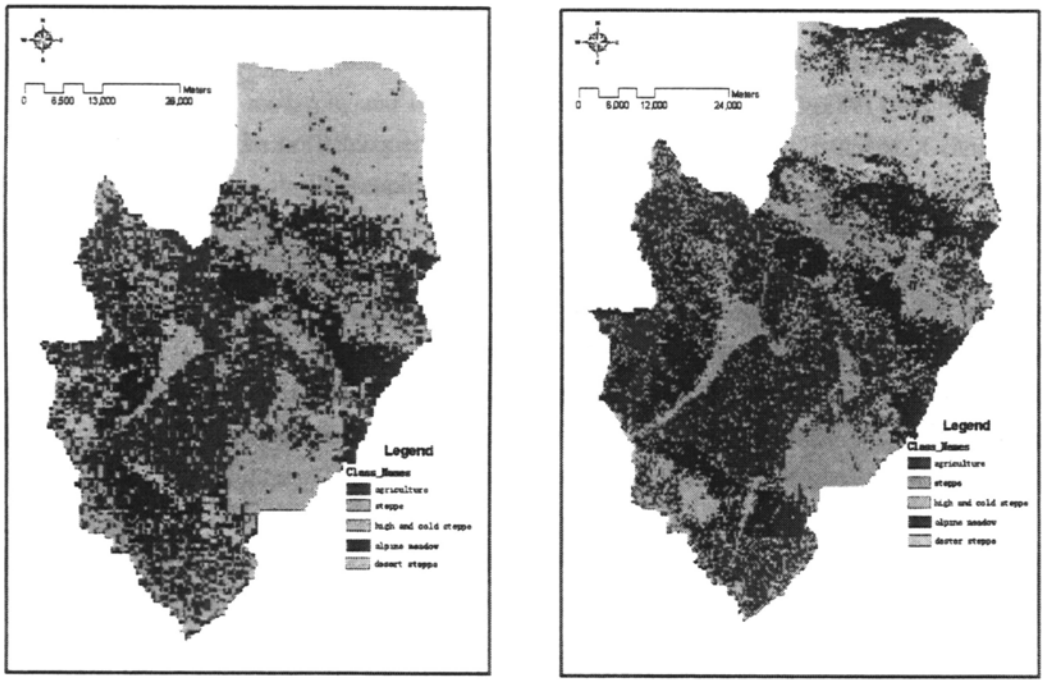


Fig 5 Land cover/use classification map

( 1986(left), 2002(right))

## 4 Result and discussion

The data for the Heihe river basin were processed by knowledge-based decision rule criteria. An example of this methodology outputs were given in Figure 5 and table 2, along with the expert classification for the area.

Table 2 Two period land cover/use types area compare in heihe river basin

| Land cover/use type | 1989 | | 2002 | |
|---|---|---|---|---|
| | Area(ha) | Percent (%) | Area(ha) | Percent (%) |
| agriculture | 87062.13 | 23.76 | 96609.13 | 26.37 |
| steppe | 53790.03 | 14.68 | 42127.88 | 11.50 |
| high and cold steppe | 44873.55 | 12.25 | 56166.58 | 15.33 |
| alpine meadow | 97504.2 | 26.61 | 110300 | 30.10 |
| desert steppe | 83157.03 | 22.70 | 61183.38 | 16.70 |

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