

# Land Use/Land Cover Classification Based on Multi-resolution Remote Sensing Data

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**Abstract:** The paper summarized pre-existing research works relating to land use/land cover classification based on multi-resolution remote sensing data. According to the features of regions, we carried out of the land use/land cover classification of level III classes in 148 group of Xinjiang agricultural reclamation eighth division. The land use/land cover classification system divided land in study area into 6 level I classes, 16 level II classes, and 22 level III classes with multi-spatial-resolution remote sensing data. Thus we set up a set of land use/ land cover remote sensing classification and corresponding code system.

**Key words:** remote sensing classification, land use/land cover, classification system, code system

## 1 Introduction

The land resource is playing an important role in production development for both nation and region. The reasonable development and protection of land resource have became key issue for human to explore. The accuracy and timely update of land use/land cover classification are be of great significance to global change, environmental monitoring, yield estimation et al. Monitoring land use / land cover via

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remote sensing imagery has the advantage of macroscopic, fast, real-time, characteristics and so on, specially over a large area. Using remote sensing data to obtain and update information may be more effective and accurate. Using single remote sensing data source to carry on the land use/land cover classification has some limitations, such as the existence accuracy is low, versatility not strong, and so on. With rapidly development of the remote sensing techniques, various kinds of remote sensing datasets appears one after another, which used in land resource investigation with different spatial scale. This research employs the different remote sensing data imagery as a foundation, induces the domestic and foreign projects and researches, related to land use/land cover classification with remote sensing solution. According to the region features, we carried out of the land use/land cover classification and the code system in Xinjiang agricultural reclamation eighth division, for satisfying the need of project research and instruct the area agricultural production.

## **2 Overview of Land use/land cover classification with remote sensing**

Using remote sensing data for establishing land use/land cover classification system is development tendency. Low spatial resolution data has the short visit cycle and has big coverage area. Low spatial resolution data is suited to big scale research of land use/land cover, such as region, intercontinental, country and so on. However, lower spatial resolution will cause the mixed pixel and be difficult to divide features of land. Medium-resolution data were more applied to establish land use/land cover classification, which satisfy the request of database and service structure. Along with the high spatial resolution data being applied, the accuracy of discretion about land types is enhancing greatly. But it has some defects, such as long visit cycle and taking massive storage space. High spatial resolution data was more used in accuracy test and training of supervises classifies in present projects and researches.

### **2.1 Land use/land cover classification based on high spatial resolution [1]~[3]**

On the high spatial resolution image, the spatial information is richer and it could reflect size, shape of the terrain features and its relations more definitely. It has been already to launch many researches in land use/land cover change with high spatial resolution image. Land classification item in “golden land” project, completed by Sichuan remote sensing center of China, which divided all land types in the study area to be 3 kinds of I class land type, 9 kinds of II class land type and 21 kinds of III class land type. Land use investigation in the LongWan power station finished by Central South University of Forestry and Technology, which divided all land types in the study area to be 3 kinds of I class land type, 9 kinds of II class land type and 35 kinds of III class land type. The project of land investigation of urban land use application in Tanggu district, Tianjin of China, which divided all land types in the study area to be 3 kinds of I class land type, 8 kinds of II class land type and 23 kinds of III class land type.

The land classification in the three projects were used QuickBird data and based on "the Nation Land classification (Implementation)" issued by Ministry of Land and Resources of China. In general, the framework of the three classification system is basically the same, have adopted three-level classification. Regarding the division of water body, three projects carried on were according to its different purposes of use. They all have division of water body in their III class land type, corresponding to agricultural land, construction land and unused land in I class land type. In addition, compared with the other two projects, the classification system was more targeted and its coverage types were more comprehensive generated by the project of land investigation in Tanggu district. For example, the division is more detailed for residential land and Independent mining land in its III class land type. Urban land was split into towns and cities in the III class land type, moreover, added salt pans and special land in it.

## **2.2 Land use/land cover classification based on medium spatial resolution [4]~[8]**

At present, medium-resolution data is applied more universal on national scale study of land use. Chinese Academy of Sciences made a land resource classification system based on TM image with the resolution of 30 m, and utilized Spot image with the resolution of 20 m to interpret key areas. It divided all land types in the study area to be 6 kinds of I class land type, 25 kinds of II class land type. Forest land in the II class land type was further divided to 3 types, such as needle forest land, broad-leaf forest land, conifer and broadleaf mixed forest, which were all included in the III class land type. In this project, Garden and forest land, mining, transportation and other types of land were merged appropriately, which enhanced operability of remote sensing classification in the I level class land type. According to the level of land use/land cover and integrating status of land use investigation, it obtained the land use/land cover types of class II.

In the project, "HuangHuaihai agricultural land variation remote sensing investigation for ten years", the Chinese Academy of Agricultural Engineering combining with sample investigation and TM multi-spectrum data, divided land of 7 provinces in HuangHuaihai area to 6 kinds of I level class land type and 16 kinds of II class land type.

National Land Cover Data, NLCD established by America, which divided all land types in the study area to be 9 kinds of I class land type, 37 kind of II class land type. The III and IV class land types could get basing on the class II for requirements. Land types of class I were extracted from TM images with the resolution of 30 m. From II to IV class land types, the land types were obtained from Aerial Images with different height of photography.

## **2.3 Land use/land cover classification based on low spatial resolution [9]~[20]**

Global Vegetation Monitoring Unit made use of SPOT / VGT data to execute the

theme of Global Land Cover2000. Its classification system was finished combining with classification software of FAO/UNEP-Land Cover Classification System and a classification system basing on data with the resolution of 1 km of International Geosphere-Biosphere Program (IGBP). In this project, land type was divided to 22 kinds on a global scale. The IGBP combining unsupervised classification and NDVI data of 12 months of a year divided the type of land use/land cover for 17 kinds on a global scale. However, the versatility of the classification system is not strong for it applying only to NOAA-AVHRR data. University of Maryland, using supervised classification, NDVI and the 41 time series images, generated by the 5 channels of NOAA-AVHRR, to produce a global 1km land cover product. Its category types is basically same as IGBP' s, when it got rid of the wetland, farmland / natural vegetation mixed, snow and ice covered the three types.

#### **2.4 Land use/land cover classification based on multi spatial resolution**

Land use/land cover (LULC) based on remote sensing data was a Land use/land cover classification based on multi-resolution, which generated by U.S. Department of Interior Geological Survey (USGS) in 1976. The classification system is divided into four. The I level class was divided with Landsat data; for the division, the data obtained at 12400m altitude or more, or less than 1:80000 scale; III level class to got data at the orbital altitude 3100~12400m, at 1:20000 scale~1:80000; IV level class to got data at 3100m orbital altitude or less, or more than 1 : 20000 scale. This classification system included 9 kinds of I level class land type, 35 kinds of II level class land type and the III, IV level class can be expanded flexibly, combining with airborne remote sensing data and ground survey and other data. [21]

Comparing to Anderson land classification system, it's more suitable for remote sensing data. The smallest unit of land cover was divided depending on the mapping scale and resolution of remote sensing data and so on. The classifications of I and II level class adapt to some researches of global or continental, while the classifications of I and II level class are suitable to some researches of regional or country wide and so on. At the same time, the system followed many features of the Anderson land classification. Such as, the first, its types named simple and easy to be accepted and used; the second, classified information can be converted or accessed any time; the third, categories can be refined downward or integrated upward. However, it took into account both land use and natural ecological background of land in I level class of Anderson land classification system, which made the relationship between categories is too complex to distinction. For example, some types were divided according to the situation of land use, such as 1 - urban or building land, 2 - agricultural land, 4 - forest land and so on. While 3 - Mountain, 6 - wetlands and 8 - tundra, which were divided according to ecological background of land resources. [22-24]

### **3 The land use/land cover classification in study area**

There are some respective flaws, existing in variety of classification systems. On the one hand, the boundaries between the two categories were not clear, so that does not apply to land cover mapping; on the other hand, the formulation of classification system is not conducive to monitoring land cover change [25]. Responding to the above problems, the study develops a more realistic and clear classification system based on existing experience and achievements.

#### **3.1 The overview of study area**

Xinjiang agricultural reclamation eighth division located at Tianshan north foothill center-section, south Songorine Basin, which is the counterpart of (Longitude): 84°58'-86°24' / (Latitude): 43°26'-45°20'. This area is a typical temperate continental climate; it has distinct arid and semi-arid characteristics for its annual rainfall of 180-270 mm and annual evaporation is 1000-1500 mm. There are 334200 ha of agricultural land including 197400 ha of arable land, 2600 ha of garden land, 27100 ha of forest land, 73900 ha of grassland and 26600 ha of construction land and so on. 148 group of Xinjiang agricultural reclamation eighth division is located 80 kilometers west of the city of Shihezi city, which is an important production base of Xinjiang agricultural reclamation eighth division. The 148 group is a large state-owned enterprise, dominated by agriculture, while combining with agriculture, forestry, animal husbandry and industry. In this group, cotton, wheat, corn, sugar beet, soybean etc were main agricultural planting. There are less land can be used in the study area, affected by drought, desertification and salinization. Low efficiency of land use, situation of the land use is incompatible with the characteristics of land resources, which is leading to poor performance of land use structure. Soil organic matter content is low and the heavy is low, however, it requires massive investment in the land development and utilization. The land use types with a vertical distribution of zonal, affected by topography and climate.

#### **3.2 Land use/land cover classification system in study area**

##### **3.2.1 The bases and principles of land use/land cover classification**

By comparing and analyzing domestic and foreign classification systems and according to the characteristic of multi-resolution, multi-time phase remote sensing data and features of district, we build the classification system for Xinjiang agricultural reclamation eighth division. The system mainly reflected the following principles: the first, the land type division need reflect consistency or similarity of land use/land cover and natural condition, as well the primary and secondary of Land utilization manner; the second, it is advantageous to the natural resource reasonable use and the protection (for example, Haloxylon, Tamarix and other vegetation with

sand-fixing role should be divided into the type of shrub land rather than grass land, even if where has been grown many kinds of thick herbaceous plants below it.) ; the third, it is necessary to give attention to the types with special significance (for example, vegetation that has the great economic value and the species gene bank function; Special industrial crop and orchard, and so on ) .

### 3.2.2 Land use/land cover type division

For meeting the requirements of desertification monitoring, sparse scrub and sparse grassland were distinguished from high canopy density of the bush and high coverage grassland by Wang Liwen. And she partitioned the land of Xinjiang into 14 kinds of type. [26]Liu Aixia who divided the land in Shihezi to be 6 kinds of land use type, including planter land for wheat, planter land for cotton, alkaline land, sand and residential land, water area, irrigable land. The classification system was built based on CBERS-1 image data, and full accounted of the local real condition, such as there are large area of sand and alkaline land and less area of forest land and grass land in the study area; and most of the remaining land is cultivated. [27] Moreover, carries on the classification through the regionalization method regarding the vegetation scarce area, may reduce the influences regarding the precision of land use/land cover classification to a certain extent, because of the local climate, the terrain, the soil and so on is created regarding the land utilization/cover classification precision. Space position knowledge of ground features is benefit to raise classified precision. For example, there are no other types except farmland, water body, garden and forest land, residential land etc; small area bare land will be used by people, distributing around towns; sand with small area can turn other land type through the government and so on. [28]

We divided the land types of land use/land cover and built a classification system with three levels, referring to "Land utilization Present situation Investigation Technical Schedule", "The Nation Land classification (Implementation)", "Remote Sensing Investigation Technology and Method for Medium and Small scale land use change", etc. It is a comprehensive kind of system, which collect land utilization and the cover in a body to instruct agricultural production and agricultural resource management.

**Table 1** Table of land use-cover classification system

| I level class |                   | II level class |                   | III level class |                   |
|---------------|-------------------|----------------|-------------------|-----------------|-------------------|
| Name          | Code of land type | Name           | Code of land type | Name            | Code of land type |
| Arable Land   | 1                 | Paddy Field    | 11                | Paddy Rice      | 111               |
|               |                   |                |                   | Cotton          | 121               |
|               |                   | Arid Land      | 12                | Corn            | 123               |
|               |                   |                |                   | Wheat           | 124               |

|                        |   |                                       |             |                             |     |
|------------------------|---|---------------------------------------|-------------|-----------------------------|-----|
|                        |   |                                       | Tomato      | 125                         |     |
|                        |   |                                       | Other Crops | 126                         |     |
|                        |   | Leisure Land                          | 13          | Leisure Land                | 131 |
|                        |   |                                       |             | Forest Land                 | 211 |
| Garden and Forest Land | 2 | Forest Land                           | 21          | Stocked Land and Shrub Land | 212 |
|                        |   |                                       |             | Vineyard                    | 221 |
|                        |   | Garden Land                           | 22          | Land for Peach              | 222 |
|                        |   |                                       |             | Other Fields                | 223 |
|                        |   | Residential, Industry and Mining Land | 31          | Residential Land            | 311 |
| Constructive Land      | 3 | Transportation Land                   | 32          | Industry and Mining Land    | 312 |
|                        |   |                                       |             | Transportation Land         | 321 |
|                        |   | Water Surface                         | 41          | Drainage and Ditch          | 411 |
| Water Body             | 4 |                                       |             | River, Lake, Basin, Pond    | 412 |
|                        |   | Shallow Seas and Tidelands            | 42          |                             |     |
|                        |   | Snow Cover                            | 43          |                             |     |
|                        |   | Natural Meadow                        | 51          | Grass Land                  | 511 |
| Grass Land             | 5 | Artificial Pasture                    | 52          | Wild Grass Ground           | 512 |
|                        |   |                                       |             | Artificial Pasture          | 521 |
|                        |   | Bare Field                            | 61          | Alkaline Land               | 611 |
| Bare Land              | 6 | Sand                                  | 62          | Other Naked Land            | 612 |
|                        |   | Bare Rock                             | 63          |                             |     |
|                        |   | Gobi Desert                           | 64          |                             |     |

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### **3.2.3 Analysis and application of the land use / land cover classification system**

#### **3.2.3.1 The analysis**

The I level class division By the land cover concept to describe natural quality of biological cover types on land surface. Dividing the I level class into 6 kinds of type, from the aspect of cover, such as the arable land, the garden and forest land, the constructive land, the water body, the grass land, the bare land, which combine with multi-time phase and low spatial resolution data, in order to reflect the land cover state in study area.

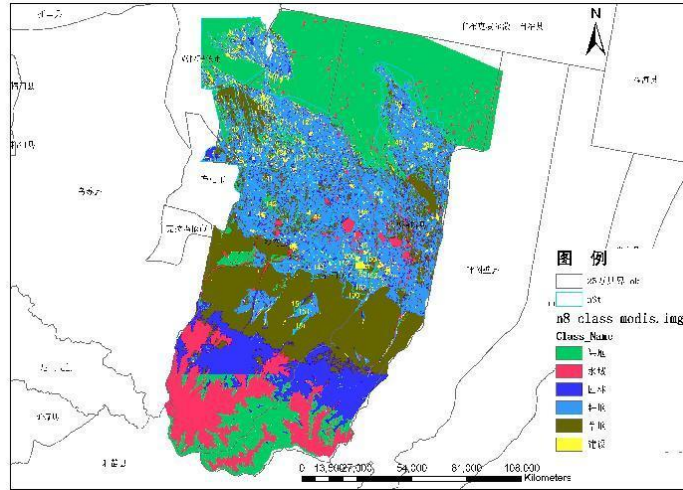
The II level class division Considered the feasibility of remote sensing technique, the interpretation accuracy, the type of land use and the degree of utilization, merged or increased the land type of II level class in former classification systems. The new system was divided into 16 kinds of type. (1)Increase the fallow land. Fallow land is frequent and it is defined that stop the cultivation more than one year of the land. Fallow land can be extracted by superposition of different time phase data. (2) Differentiates the field and the forest land. It is easily to pick-up types of the garden land and the forest land from remote sensing image, according to the local planter pattern and certain space position knowledge. (3)The combination of the rivers, the lake, the basin and the pond, may strengthen the feasibility about technical processing, simultaneously also satisfies the actual need in agricultural production. (4)Distinguish the artificial pasture and the natural pasture. The animal husbandry was one of important industrial, so artificial pasture is becoming a more necessary land type in the study area. The artificial pasture is neater, can satisfied the accurate request of extraction.

The III level class division Taken 148 groups as the key research region and considered that land type's use process since long, the agriculture resource protection and the planter management's need, detail classified the types of III level class by high resolution remote sensing data into 22 kinds. In the sub-category of the garden land and the forest land, which were all based emphasizing respective function. That is to emphasize its products, application and so on.

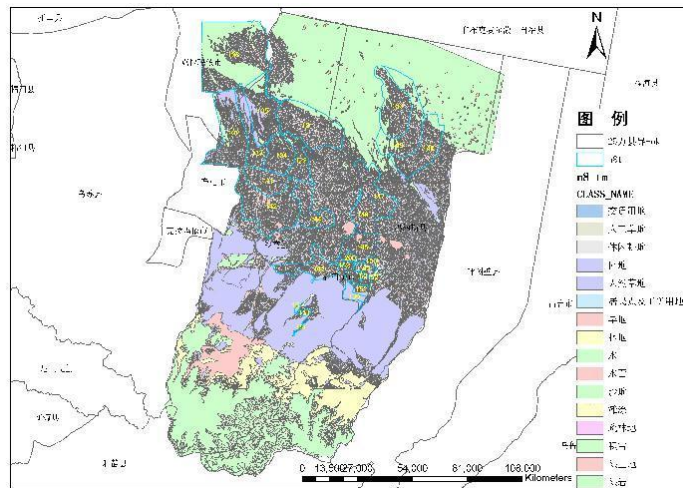
#### **3.2.3.1 The application**

Taking the new land use/land cover classification as a foundation, carry on the I and II level classes division to agricultural reclamation eighth division of Xinjiang and the III level class division to 148 group of Xinjiang agricultural reclamation eighth division. Namely, take NDVI time series of MODIS separately as the classified characteristic to various terrain features category degree of membership function for gaining the I level classification result; According to the different classified object and choosing the decision tree construction method which based on knowledge and samples, as well as the man-machine interactive way, gain the II level classification result with TM data; gain the III level classification result with Rapideye data. (Classified result as shown in picture 1, picture 2 and picture 3)

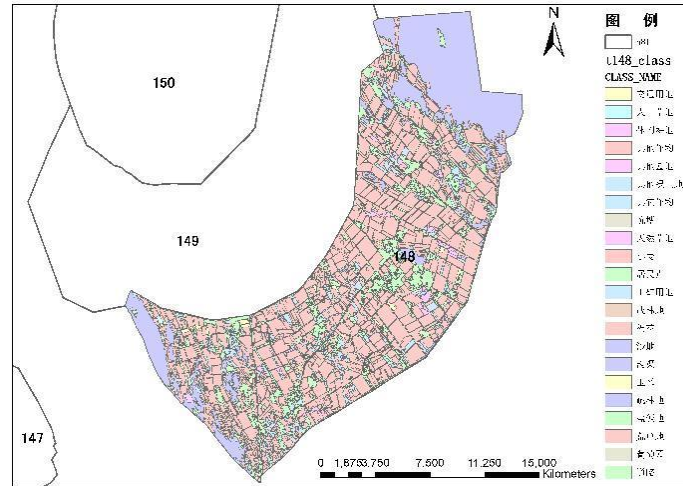




**Picture 1** Agricultural reclamation eighth division land use/land cover remote sensing classification result in 2010 ( I level class)



**Picture 2** Agricultural reclamation eighth division land use/land cover remote sensing classification result in 2010 ( II level class)



**Picture 3** Agricultural reclamation eighth division land use/land cover remote sensing classification result in 2010 (III level class)

#### 4 Conclusions

(1) The multi-phase and multi-resolution data can display its superiority fully for land types changed along with season factors, the transition region among different cover types and classification in different scales to establish the classification system.

(2) The land use/land cover classification system was produced, which was based on cover status and land use condition in the study area. In this system, to a certain extent, avoided crossing and confusion categories of status, with clear relationship between classes, been helpful for subprime type of classification.

(3) Considering maneuverability of using remote sensing technology to discriminate land types and cover degree of land use types, reasonable merged or increased in previous classification system of II level land type. Namely, divided the new system, needed to achieve the combination similarity and the distinguish diversity, by large to small, by senior to lower. Eventually, built a associated, logical and scientific classification system, facilitate land cover remote sensing monitoring and conventional data sharing between land use status investigation.

(4) The way of classification according to the land use/land cover status, was helped to control and supervision the main quantity about land use types and the implementation of the plans.

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