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# ANALYSIS ON SPATIAL DIFFERENCE OF LAND USE CHANGE BASED ON PHYSICAL AND CULTURAL LANDSCAPE ATTRIBUTES
## —A Case Study at Mongolian Autonomous County of Qian Gorlos, Jilin Province

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**ABSTRACT**: Land use changes are regarded as landscape pattern change driven by many interactive natural and social-economic factors. Different combination of physical geographical elements induced the difference of spatio-temporal pattern of land use change. There are four physical geographical regions in Mongolian Autonomou County of Qian Gorlos of Jilin Province. Based on spatial analysis and statistical analysis, we conclude that the primary pattern of land use and the tendency of land use changes are all different in four physical geographical regions. During 1987 – 1996, the dominant land use change processes were from grassland or forest to arableland, from unused land to paddy and grassland to unused land. Though land use change is mainly affected by social and economic condition in short period, the composite characters of physical geographical elements controls land use dynamic process. The relationship between land use dynamic process and the character of physical geographical units differ in different regions. Possible human impacts on land use change are explored with application of buffer areas of series distance along main roads and radius around main settlements. A few models are built to describe the relationship between land use spatial change rates and distance to road and settlements. According to our result, the relationship with the proximity to roads was a negative liner function, with the change rate decreasing rapidly when moving away from roads. Within a distance of less 7. 5km from main traffic lines, land use changes occur red more. The bulk of grassland was apt to be opened up for cultivation around the settlements and the transformation from dryland to paddy occurred within the distance of 1km away from settlements.

**KEY WORDS**: land use change; physical geographic region; land use dynamic process; effective coefficient; cultural landscape variable

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Land use changes are regarded as landscape pattern change driven by many interactive natural and social-economic factors(JACQUES, 1999; JOHANN *et al.*, 1999), and show the competition between land use types under different conditions. Socio-economic attributes contribute to land use/cover change in short period(BENOIT *et al.*, 1999; TURNER *et al.*, 1995), whereas physical conditions constrain essential change tendency and change process. The spatial difference in land use dynamic in Mongolian Autonomous County of Qian Gorlos, Jilin Province is discussed in this paper. The spatial difference of land use change processes depends on the composite characteristics of physical geographic elements. As human driving forces, the traffic and settlement condition impact the distribution of land use transformation rate among different land use types as well.

## 1 STUDIED AREA

The studied area is located in Mongolian Autonomous County of Qian Gorlos of Jilin Province on the fringe of the Songnen Sandy Land, which covers an area of 6029.4km$^2$ between 124°10′E – 125°02′E, 44°18′N – 45°28′N. It belongs to the semi-humid and semi-arid continental monsoon climatic region. Annual average temperature is 4.5℃, ≥10℃ accumulative temperature is 2948℃, annual average precipitation is between 400 and 600mm decreasing from southeast to northwest. The Second Songhua River and the Nengjiang River flow across the east and north parts of this county. About 200 ponds distribute in central or north area, where underground water level and degree of mineralization are higher than that in the southwest. The main landform types include floodplain, alluvial plain, terrace, table land, sandy dune and intervale. The soil type is dominated by chernozem. Sandy soil, paddy soil, meadow soil and saline-alkaline soil can also be found. Based on the integrative characteristics of above physical elements, the whole area are divided four physical geography regions, that is, floodplain alluvium - meadow soil region along river, central-north alluvial plain saline-alkaline soil region, west terrace sandy soil region and south table land chernozem region.

## 2 METHOD

### 2.1 Data and Its Process

Land use was studied on the basis of the digital data of Landsat TM band 2, 3, 4 (May 1987 and 1996) covered Mongolian Autonomous County of Qian Gorlos. Topographic maps of 1: 100 000 scale was available. The physical geographic division map, traffic map and related thematic maps and statistics materials were also used. According to national common classification system and the physical circumstances in study

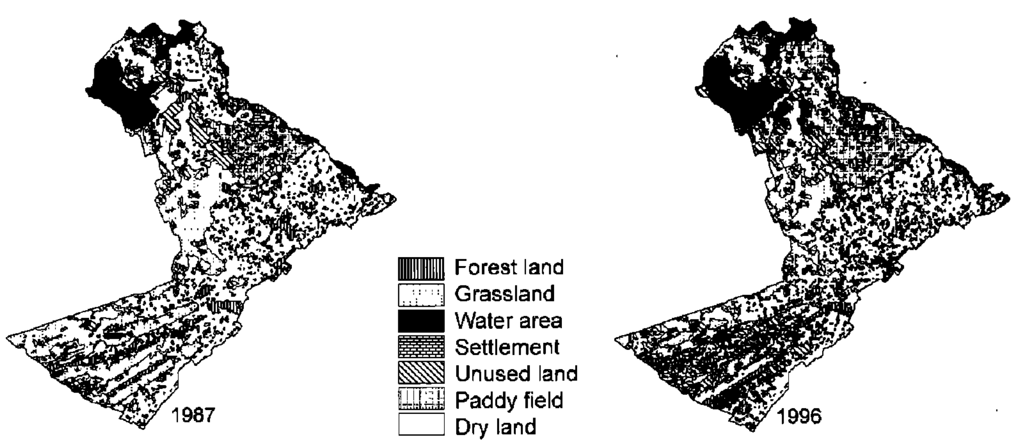


Fig. 1 Land use of Mongolian Autonomous County of Qian Gorlos in 1987 and 1996

area, the land use included seven types: dryland, paddy, forest, grassland, water, residential and construction land and unused land.

To analyses the remote-sensing data, PCI software was used to rectify and strengthens TM images. Visual interpretation, followed by screen digitizing was applied to obtain digital data of land use in 1987 and 1996 ( Fig. 1).

## 2. 2 Data Analyses

### *2. 2. 1 Spatial analyses*

Under the Arc/Info support, overlay analysis was conducted first to get a composite data with different land use types for the year of 1987 and 1996. The basic pattern and changing tendency of land use in each physical geographic region were then estimated by overlying physical geographic division map with land use maps in 1987 and in 1996 and the change map during the study period respectively. To explore the possible human impacts on land use/cover change spatial difference, buffer areas of different distance from main roads and series radius around main settlements were generated and overlaid with the change map.

### *2. 2. 2 Tendency simulation*

Since land use distribution is continually changing over time, its dynamic show the characteristics of Markov process. To model the dependent relationships of land use change in each physical geographic region over 1987 – 1996, the transitional probability matrices were calculated from the attribute table of the composite data layer of change map and physical geographic division map(ZHANG *et al.*, 1999) . The transitional probability were defined as the percentage of the transformed area from land use type $i$ to $j$ during the period 1987 – 1996 of area of type $i$ ,

$$P_{ij} = A_{ij} / A_i$$

where $P_{ij}$ is the transitional probability from type $i$ to $j$ over the study period, $A_{ij}$ represents transformed area from type $i$ to $j$, $A_i$ is the area of land use type $i$ at the beginning of the study period(XU *et al.* 1993).

### *2. 2. 3 Effective coefficient computation*

Owing to the differences of each physical element and their spatial composite pattern, the whole character and main physical geographical process differ from each other in physical geographic regions, whereby the land use change process and tend show various features (PAN *et al.*, 1999). To examine the relationships between land use change process and integrative feature in each physical geographic region, the effective coefficient was given by the following formula:

$$E_{ij} = \ln[(r_{ij})(1 - p_j)/(p_j)(1 - r_{ij})]$$

where $E_{ij}$ was the effective coefficient for dynamic course type $i$ to physical geographic region $j$, $r_{ij}$ was the proportion of dynamic course type $i$ in geographic region $j$ and $p_j$ was the proportion of the total study area occupied by the physical geographic region $j$. $E_{ij}$ greater than 0 indicates the land use dynamic course type $i$ has significant correlation with the attributes in physical geographic region $j$, which demonstrates this change course is constrained by this certain physical geographic region.

### *2. 2. 4 Univariate model*

The spatial occurrences of land use change are correlated with cultural landscape variables such as traffic lines and settlements location. Univariate models were built to describe the relationship between a measure of land use transformation rate and distance to main roads or to main settlement. The following formulas were given to calculate land use total change rate $C$, change rate of land use type $i$ $C_i$ and transformation rate from type $i$ to $j$ $T_{ij}$.

$$C = \frac{\text{changed area in buffer area}}{\text{buffer area}}$$

$$C_i = \frac{\text{changed area of land use type } i \text{ in buffer area}}{\text{total changed area in buffer area}}$$

$$T_{ij} = \frac{\text{transformed area from land use type } i \text{ to type } j}{\text{total changed area in buffer area}}$$

## 3 RESULTS

### 3.1 General Patterns of Land Use in Different Physical Geographic Regions

The general structures of land use differ in each physical geographic region. The area percentage and patch compositions for the land use types are shown in Fig. 2. The floodplain alluvium-meadow soil region is along Sonhua River and Nenjiang River, whose average elevation is 130m. Alluvium soil, meadow soil and swamp soil developed on different microtopography situs. Hygrophilous meadow vegetation is favorable here. Arable land (paddy field and dryland) is dominant land use and distributes widely.

The central-north alluvial lacustrine plain saline-alkaline soil region is composed of alluvial or lacustrine plain and paleochannels lowland. The elevation is between 126m to 140m. Big or small ponds and lakes scatters in whole area, wherein the underground water level and degree of mineralization are high. Halophytes grow in saline-alkaline soil. Each land use is well proportioned in this area.

Terrace plain, sandy dune and low-lying land constitute the west terrace plain chernozem sandy soil region, where elevation is about 140 – 180m. The sandy soil distributes on the sandy dune, while light-chernozem evolved from the Quaternary loess-like clay are on the low interdunes or terrace plain. Grassland and dryland occupy more than 30% and 40% of this total region.

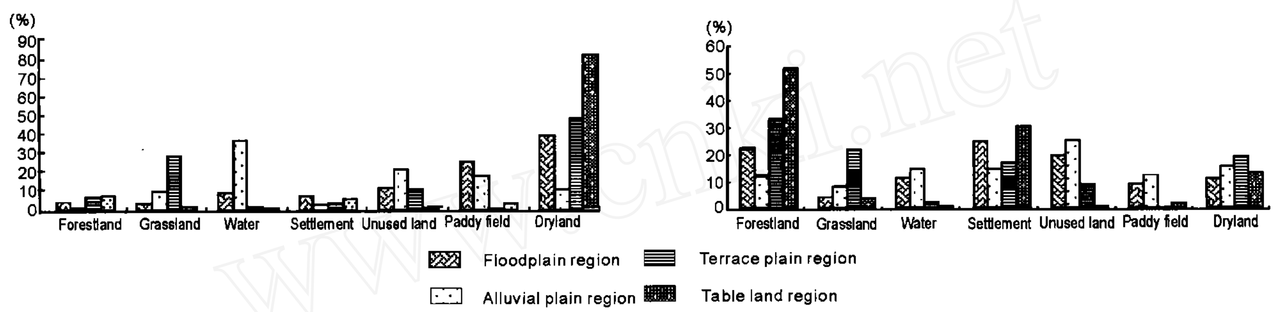


Fig. 2 Area and patch composition of different physical geography regions

In the south table land chernozem soil region where the elevation is 180 – 260m, the alfisol chernozem are developed. Natural steppe vegetation has been mostly cultivated. Dryland is the most abundant land use type, while other types are mosaics in dryland area.

### 3.2 The Trend of Land Use Transformation

Not only the general pattern but also the change courses between land use types are different in geographic regions. The area of changes fluctuated through time, and the transition matrix (Table 1, Table 2, Table 3 and Table 4) highlighted the dominant dynamic event during the study period. The higher $P_{ij}$ was, the more occurrence of land use change course was.

During 1987 – 1996, the higher changing rates were from grassland or paddy to unused land, unused land was cultivated to paddy as well in floodplain region. The dominant dynamic courses in central north alluvial plain region were from grassland to unused land and from unused land to paddy. In west terrace plain region, large area of grassland degraded to unused land and forestland transformed to arable land. The main trend of land use change in south tableland area was from dryland and unused land to paddy.

### 3.3 The Relationships Between Physical Geographic Regions and Land Use Dynamics

The driving forces of land use/cover change are numerous and complicated, while physical elements and their spatial configuration constrain land use possible dynamics. In Mongolian Autonomous County of Qian Gorlos the complexity and variability of geographical attributes cause the difference in land use change. $E_{ij}$, the effective coefficient was used to describe the relationship between land use dynamic process and physical geographic units. According to data

Table 1 Transition matrix of land use on floodplain alluvium-meadow region

| 1987 \ 1996 | Forest land | Grassland | Water | Settlement | Unused land | Paddy field | Dryland |
|---|---|---|---|---|---|---|---|
| Forestland | 0. 614 | 0. 027 | 0. 026 | 0. 000 | 0. 154 | 0. 025 | 0. 154 |
| Grassland | 0. 008 | 0. 292 | 0. 203 | 0. 007 | 0. 250 | 0. 090 | 0. 158 |
| Waters | 0. 010 | 0. 016 | 0. 901 | 0. 000 | 0. 055 | 0. 013 | 0. 006 |
| Settlement | 0. 002 | 0. 000 | 0. 001 | 0. 844 | 0. 061 | 0. 008 | 0. 084 |
| Unused land | 0. 016 | 0. 013 | 0. 077 | 0. 008 | 0. 500 | 0. 268 | 0. 119 |
| Paddy field | 0. 013 | 0. 011 | 0. 063 | 0. 006 | 0. 409 | 0. 219 | 0. 097 |
| Dryland | 0. 021 | 0. 012 | 0. 013 | 0. 007 | 0. 040 | 0. 158 | 0. 748 |

Table 2 Transition matrix of land use on alluvium-saline-alkaline region

| 1987 \ 1996 | Forest land | Grassland | Water | Settlement | Unused land | Paddy field | Dryland |
|---|---|---|---|---|---|---|---|
| Forestland | 0. 799 | 0. 016 | 0. 028 | 0. 000 | 0. 025 | 0. 014 | 0. 118 |
| Grassland | 0. 009 | 0. 420 | 0. 024 | 0. 000 | 0. 355 | 0. 114 | 0. 079 |
| Waters | 0. 002 | 0. 000 | 0. 853 | 0. 000 | 0. 128 | 0. 000 | 0. 017 |
| Settlement | 0. 000 | 0. 000 | 0. 000 | 0. 868 | 0. 088 | 0. 030 | 0. 014 |
| Unused land | 0. 002 | 0. 041 | 0. 188 | 0. 003 | 0. 492 | 0. 226 | 0. 048 |
| Paddy field | 0. 006 | 0. 000 | 0. 005 | 0. 007 | 0. 051 | 0. 929 | 0. 001 |
| Dryland | 0. 017 | 0. 070 | 0. 080 | 0. 009 | 0. 144 | 0. 092 | 0. 588 |

Table 3 Transition matrix of land use on terrace chernozem-sandy region

| 1987 \ 1996 | Forest land | Grassland | Water | Settlement | Unused land | Paddy field | Dryland |
|---|---|---|---|---|---|---|---|
| Forestland | 0. 563 | 0. 104 | 0. 002 | 0. 001 | 0. 007 | 0. 000 | 0. 322 |
| Grassland | 0. 013 | 0. 579 | 0. 013 | 0. 002 | 0. 205 | 0. 000 | 0. 189 |
| Waters | 0. 010 | 0. 161 | 0. 489 | 0. 000 | 0. 164 | 0. 000 | 0. 176 |
| Settlement | 0. 000 | 0. 000 | 0. 000 | 1. 000 | 0. 000 | 0. 000 | 0. 000 |
| Unused land | 0. 002 | 0. 256 | 0. 003 | 0. 001 | 0. 597 | 0. 000 | 0. 141 |
| Paddy field | 0. 000 | 0. 000 | 0. 000 | 0. 000 | 0. 000 | 1. 000 | 0. 000 |
| Dryland | 0. 034 | 0. 052 | 0. 001 | 0. 002 | 0. 006 | 0. 000 | 0. 905 |

shown in Table 5, the transformation from unused land to paddy was closely related to the floodplain unit during the study period. The significant relationship between the change from grassland, dryland and water to unused land, grassland and unused land to paddy and composite physical geographic attributes were detected in central north plain region. In west terrace plain, except the dynamic course of forestland to grassland and dryland to forestland, other $E_{ij}$ were greater than 0 and reflected highest potential of deforestation. Because of $E_{ij}$ = 3. 84, the change processes between forestland and dryland were positively correlated with the nature features of south tableland.

### 3. 4 Land Use Changes Spatial Distribution and Human Factors

According to our result, the relationship with the proximity to roads was a negative liner function, with the change rate decreasing rapidly when moving away from roads (Fig. 3). Within a distance of less 7. 5km from main traffic lines, land use changes occur red more. The change rate distribution of land use was different. For example, forest dynamic showed a fluc-

Table 4 Transition matrix of land use on table land chernozem region

| 1987 \ 1996 | Forest land | Grassland | Water | Settlement | Unused land | Paddy field | Dryland |
|---|---|---|---|---|---|---|---|
| Forestland | 0.531 | 0.009 | 0.000 | 0.001 | 0.026 | 0.000 | 0.434 |
| Grassland | 0.028 | 0.759 | 0.000 | 0.000 | 0.000 | 0.192 | 0.021 |
| Waters | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Settlement | 0.002 | 0.000 | 0.000 | 0.993 | 0.001 | 0.000 | 0.005 |
| Unused land | 0.000 | 0.002 | 0.018 | 0.000 | 0.751 | 0.225 | 0.004 |
| Paddy field | 0.000 | 0.005 | 0.008 | 0.000 | 0.011 | 0.946 | 0.029 |
| Dryland | 0.014 | 0.001 | 0.000 | 0.002 | 0.001 | 0.001 | 0.981 |

Table 5 Effective coefficients of land use change process in different physical region

| Physical geographic region | Dominant landuse change course | $E_{ij}$ | Physical geographic region | Dminant landuse change course | $E_{ij}$ |
|---|---|---|---|---|---|
| Floodplain | Grassland-paddy field | −0.757 | Central north aluvial plain | Grassland-unused land | 2.210 |
| | Unused land-paddy field | 1.321 | | Grassland-paddy field | 0.351 |
| | Paddy-unused land | 1.866 | | Grassland-dryland | −0.096 |
| | Dryland-paddy field | −0.525 | | Water-unused land | 3.669 |
| West terrace plain | Forestland-grassland | −0.252 | | Unused land-water | 1.227 |
| | Forestland-dryland | 1.399 | | Unused land-paddy field | 1.537 |
| | Grassland-unused land | 0.309 | | Forestland-dryland | 1.132 |
| | Grassland-dryland | 0.151 | South table land | Forestland-dryland | 3.840 |
| | Unusedland-grassland | 0.921 | | Dryland-forestland | 2.383 |
| | Dryland-grassland | 0.556 | | Unused land-paddy field | −0.145 |
| | Dryland-Forestland | −0.207 | | Dryland-paddy field | −0.312 |

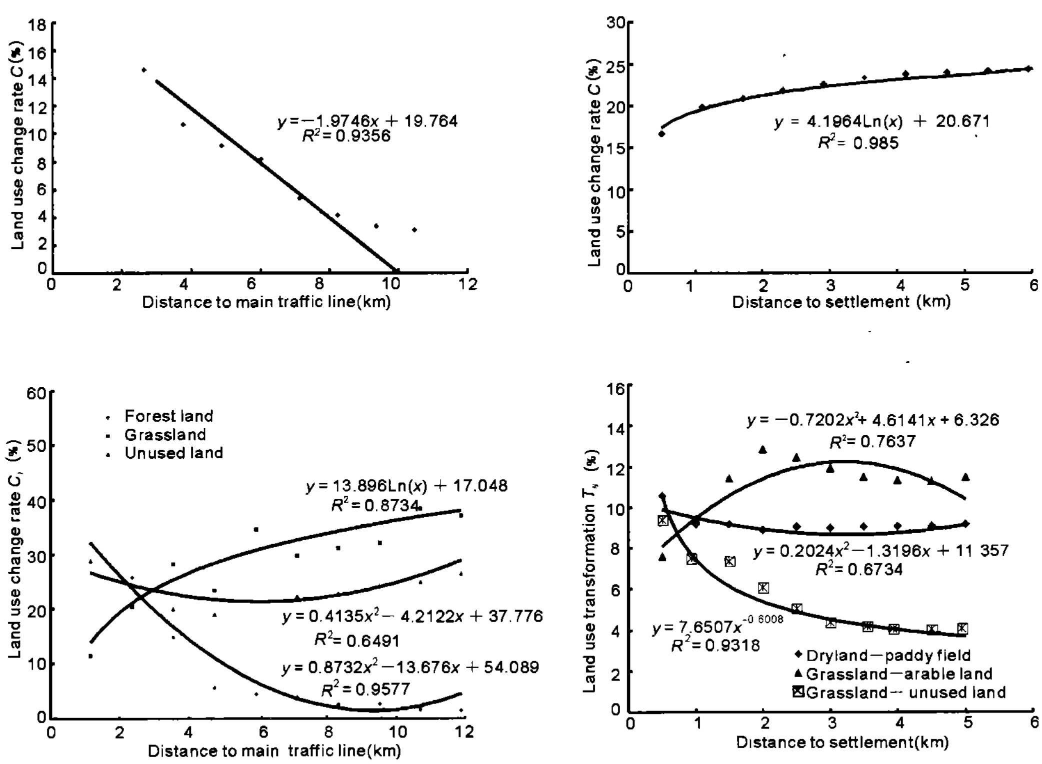


Fig. 3 The relationship between land use transformation rate and distance to main road or to nearest settlements

tuating trend, i. e. decreasing within 8km then increasing beyond that distance. While the change rate of unused land was negatively correlated with the distance to main traffic lines. The relationship with the proximity to main settlements confirmed that dominant changes occurrences are spatial differently. The change rate increased gradually within 3km. The bulk of grassland was apt to be opened up for cultivation. Due to excessive grazing, the grassland suffered from desertification, alkalization and degradation around the villages. The distribution of transformation from dryland to paddy occurred within the distance of 1km away from settlements.

## 4 CONCLUSION

The spatial difference of land use change is closely related to natural and cultural driving forces. Because of the complicity and variability of physical geographic attributes, the integrative character in different physical units constrains the change process as a stable factor. In each physical region of Mongolian Autonomous County of Qian Gorlos, the land use structure and change pattern and trend were different. During 1987-1996, the dominant land use change processes were from grassland or forest to arableland, from unused land to paddy and grassland to unused land. Each change course between land use types depended on the composite characters in physical geographic regions. As cultural landscape attributes, roads and settlements affected by spatial distribute of land use change course. In different impacting distance, the change activity was various.

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