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Analysis and Prediction of Land Use Dynamic Change in Pisha Sandstone Area of Ordos Plateau in China in Recent 20 Years

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Abstract:
The study on landuse dynamic change takes an important position in global and regional environmental change and sustainable development research. In this study, the Ordos Pisha sandstone area in China was selected as the research object. The landuse type maps for different time frames were obtained by remote sensing classification method, and the change information was extracted for analysis and prediction of variation of landuse from the aspects of area, structure and dynamic change. Studies have shown that: (1) The total area of landuse has remained the same for 20 years recently. (2) The urban construction intensity of the area has been growing year by year, and the increased construction land is mainly from grassland. (3) Dynamic changes in construction land are the main factors affecting landuse change in the area. (4) If the rate of change remains the same, by 2030, the area of farmland, woodland, grassland, waters, construction and un-utilized land in Pisha sandstone area will be 3242.70km2, 870.82 km2, 10014.68 km2, 467.14 km2, 1157.06 km2, 993.48 km2, respectively. The research results can help fully understand the characteristics and trends of landuse change in this area, and provide effective scientific and technological support for regional ecological environmental protection and sustainable landuse.

Keywords: *Pisha sandstone, Landuse, Dynamic change, Markov model, Ecological*

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

environment, Sustainable development.

I. INTRODUCTION

Land use /cover change (LUCC) is a reflection of the interaction between human beings and their living environment in the land resource system. The ecological and environmental problems caused by the unbalanced development of landuse types have always been one of the hotspots in LUCC research [1-4]. Based on the rapid development of 3S technology, relatively mature methods have been developed in qualitative or quantitative analysis and evaluation of landuse dynamic change, evolution trend, pattern change and so on[5-7]. There are also various studies on LUCC, such as the relationship between LUCC and land degradation, soil erosion, surface runoff, carbon flux and ecosystem services.

Despite numerous studies on LUCC, there are very few studies involving Pisha sandstone areas of Ordos, China. At present, there are only a few small watershed-scale landuse studies, and there is no research on landuse and prediction of the whole Pisa sandstone area.

Pisha sandstone is concentrated in the Ordos Plateau of China, which is in the northern of the Loess Plateau in the border area of Shanxi, Shaanxi and Inner Mongolia.

This area features extremely fragile ecological environment and most severe soil erosion on the Loess Plateau, which provides the main source of coarse sediments of the Yellow River. Pisha sandstone is a kind of loose rock, which is terrestrial clastic rock series. Because of small thickness and low pressure of the overlying strata, the degree of diagenesis is low, the degree of cementation between sand grains is poor, and the structural strength is low. When water meets, it becomes mud and when wind meets, it becomes sand. The special physical and chemical properties of Pisha sandstone lead to extremely serious soil erosion in the Ordos Pisha sandstone area, which has gradually aroused the concern of experts and scholars.

In this study, the Ordos Pisha sandstone area in China was selected as the research object. The landuse status maps of various periods in the past two decades were obtained by remote sensing classification method, and the temporal and spatial variation characteristics of landuse were analyzed and predicted. Studying the landuse change characteristics and development trends in the area carries great significance for reducing soil erosion, promoting regional ecological environmental protection.

II. MATERIALS AND METHODS

2.1 Overview and Data Sources

2.1.1 Overview

Pisha sandstones are concentrated in Dongsheng District, Jungar Banner, Ejin Horo Banner, Dalad Banner and Haggin Banner in Erdos City, Inner Mongolia Autonomous Region, China as well as Shenmu and Fugu counties of Shaanxi Province, Hequ, Baode counties and Qingshuihe County of Shanxi Province. According to the land cover degree, it can be roughly divided into three types of areas, namely, bare Pisha sandstone area, soil cover area and sand cover area,

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

with a total area of 16,700 km2. The study area faces fragile ecological environment and extremely serious soil erosion, whose ecological environment needs urgent treatment. The location is shown below in Figure 1.

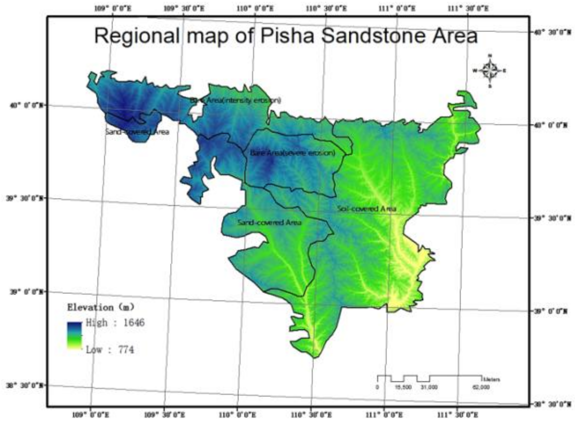

Fig 1: Regional map of Pisha Sandstone Area

2.1.2 Data and Image Processing

Remote sensing images with a resolution of 30m in 2000, 2005, 2010 and 2015 were selected. Atmospheric correction and geometric correction were performed, and the study boundary is determined. According to the existing three-level classification system of national land resources, land use reclassification of this area was performed, landuse maps were made and landuse area data was extracted for analysis. The landuse map is shown in Figure 2.

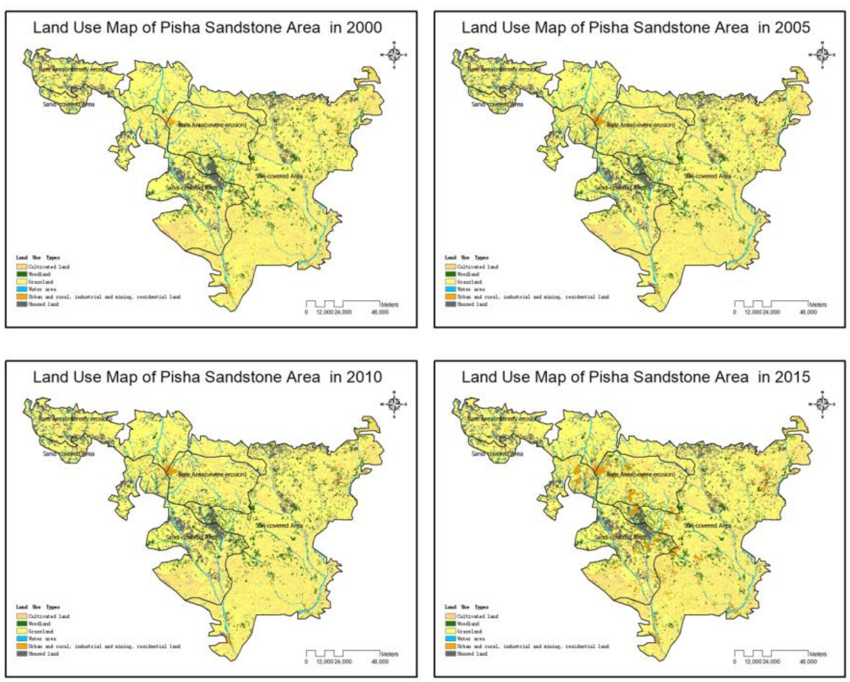

Fig 2: Landuse map of Pisha Sandstone Area in 2000- 2015

2.2 Analysis and Prediction

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

2.2.1 Analysis of Changes

In order to extract the information on the change of landuse, it is necessary to first obtain the data of various landuse areas in different periods and calculate the landuse type area and change rate in 2000, 2005, 2010 and 2015 based on the results of classification of landuse remote sensing images, as shown in TABLE I and TABLE II.

TABLE I. Landuse area table of Pisha Sandstone Area (unit: km^2)

Area	**2000**	**2005**	**2010**	**2015**
Farmland	3398.53	3426.03	3361.06	3310.39
Woodland	742.42	814.75	831.95	815.71
Grassland	10863.67	10723.25	10754.79	10406.55
Waters	498.41	493.55	486.31	478.78
Construction land	250.49	256.44	291.27	739.86
Un-utilized land	992.35	1031.85	1020.5	994.58
Total	16745.88	16745.88	16745.88	16745.88

TABLE II. Table of Landuse Type Area Change Rate in Pisha sandstone Area

Landuse type	Landuse type change rate (%)			
	2000-2005	2005-2010	2010-2015	2000-2015
Farmland	0.81	-1.9	-1.51	-2.59
Woodland	9.74	2.11	-1.95	9.87
Grassland	-1.29	0.29	-3.24	-4.21
Waters	-0.98	-1.47	-1.55	-3.94
Construction land	2.38	13.58	154.01	195.37
Un-utilize land	3.98	-1.1	-2.54	0.22
Total	0	0	0	0

It can be seen from TABLE I and TABLE II that the total Pisha sandstone area remains unchanged from 2000 to 2015, which is 16,700 km2. Where, the annual scale of landuse type area is unchanged in the order of: grassland > Farmland > Un-utilized land > woodland > waters > construction land. In the statistics of the past two decades, although the total Pisha sandstone area has remained unchanged, the inter-annual variation trend of each landuse type has changed significantly. The landuse area of each type had changes in different amplitudes in the past 20

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

years, especially construction land. This indicates that human activities in the area bring a greater impact on the change of landuse area, also showing that human activities exert particularly significant effect on environmental changes in Pisha sandstone area. The area change of each landuse type is analyzed as follows:

(1)Farmland: Except the certain increase in farmland area in 2000- 2005, the farmland area gradually decreased in 2005-2015, with 1.90% decrease in 2005 -2000 and 1.51% decrease in 2010-2015. The main reason is analyzed to be land reduction caused by soil erosion and invasion of construction land.

(2)Woodland: The woodland area had increased in 2000- 2010, with an increase of 9.74% in 2000-2005 and an increase of 2.11% in 2005-2010. It declined in 2010-2015, with a decrease of 1.95%. In 2000-2005, the woodland area increased substantially, which is considered as related to reduction of water area and grassland area. Also, large-scale afforestation played an important role in increasing woodland area. Woodland continued to grow in 2005-2010, but with noticeably slow growth rate, which may be due to inability to expand indefinitely given the limited plantable woodland area. In 2010-2015, woodland showed very obvious downward trend, which was considered as related to the substantial increase in building area and the invasion of woodland by construction land within the five years.

(3)Grassland: In 2000-2015, the total grassland area decreased first, then increased and then decreased. Where, in 2000-2005, there was 1.29% reduction, which was considered as related to the substantial increase in woodland after some grasslands were restored to woodland. In 2005-2010, the grassland area increased slightly, with an increase of 0.29%, which was considered as related to the reduction of cultivated land, water area and farmland returning to woodland. In 2010-2015, the grassland area decreased significantly, down by 3.24%, which was analyzed as correlated to invasion of construction land.

(4)Construction land: The total construction land area has increased significantly in the past 20 years, showing a gradual growth trend, with most obvious change in 2010-2015 when increase was up by 154.01%, indicating that the country's construction in Pisha sandstone area has been significantly strengthened. The increase in construction land directly leads to the decline of several other land types.

(5)Waters: The total waters area has reduced slightly and the overall changes have stabilized, which is considered as related to the changes in construction land.

(6) Un-utilize land: The un-utilized land area increased in 2000-2005, and the area showed a downward trend thereafter, indicating that the development level in Pisha sandstone area is deepening.

In general, the total Pisha sandstone area has remained unchanged in recent 20 years, and the area of farmland, grassland and waters has been decreasing year by year; the area of woodland, construction and un-utilized land has increased, especially the area of construction land.

2.2.2 Spatial Changes in Landuse Structure

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

It is difficult to reflect the internal structural changes of landuse solely from the increase or decrease of land type area. In order to report the transfer characteristics between landuse types more clearly, according to the landuse maps of Pisha sandstone areas in 2000, 2005, 2010 and 2015, classification maps in the four different periods were superimposed in pairs using spatial superposition analysis function in ARCGIS software, finally obtaining the landuse area transition matrix. The transition matrix can comprehensively analyze the structural characteristics of regional landuse change and the direction of landuse type change. It can reflect the landuse type structure in the initial and final stages of the study, and can also report the transfer and change of landuse types during the study period, so that it is easy to understand the direction and source of landuse types at different study periods. (1)Landuse transfer in 2000-2005

As shown in TABLE III and TABLE IV, in 2000- 2005, mutual transformation exists in various landuse types.

The unchanged areas of farmland, woodland, grassland, waters, construction and un-utilized land in Pisha sandstone area were 2611.96 km2, 627.93 km2, 9897.41 km2, 428.81 km2, 213.14 km2 and 925.6 km2, respectively. In general, the area of grassland and waters decreases, while the others increase. In particular, the grassland decreases significantly in the past five years, with a total reduction of 140.43km2. It is speculated that the degraded grassland resources is a result of excessive human activities such as reclamation, afforestation and urban construction, indicating that the grassland ecological fragility in Pisha sandstone area is not suitable for large-scale development.

TABLE III. Transition matrix table of landuse in Pisha Sandstone Area in 2000 - 2005 (unit: km^2)

2005 / 2000	Farmland	Woodland	Grassland	Waters	Construction land	Un-utilized land	Total
Farmland	2611.96	52.14	670.81	30.50	18.31	14.82	3398.53
Woodland	44.37	627.93	56.21	4.28	6.94	2.69	742.42
Grassland	727.41	112.51	9897.41	24.87	15.77	85.71	10863.67
Waters	20.29	13.82	33.35	428.81	1.04	1.09	498.41
Construction land	14.09	0.77	16.67	3.87	213.14	1.94	250.49
Un-utilized land	7.91	7.57	48.80	1.22	1.24	925.60	992.35
Total	3426.03	814.75	10723.25	493.55	256.44	1031.85	16745.88

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

TABLE IV. Direction table of land transfer in Pisha Sandstone Area in 2000-2005 (unit: km^2)

Land type	New area	Transfer area	Unchanged	Change area
Farmland	814.07	786.58	2611.96	27.49
Woodland	186.81	114.49	627.93	72.32
Grassland	825.84	966.27	9897.41	-140.43
Waters	64.74	69.59	428.81	-4.85
construction land	43.3	37.34	213.14	5.96
Un-utilized land	106.25	66.74	925.6	39.51

(2) Analysis of landuse transfer in 2005-2010

According to the data in TABLE V and TABLE VI, there are respectively 2694.46km2, 736.79km2, 9921.39km2, 447.14km2, 241.33km2 and 978.24km2 of farmland, woodland, grassland, waters, construction and un-utilized land which remains unchanged in Pisha sandstone area in 2005-2010. Transfer in most landuse types has been relatively complementary, with only significant changes between grassland, farmland, construction and un-utilized land. 48.79km2 of farmland is converted into grassland, 25.95km2 of grassland is converted into unused land while 25.71km2 of grassland is converted into construction land. In general, the area of farmland, waters and un-utilized land shows a decreasing trend, while that of woodland, grassland and construction land shows an increasing trend. Farmland has the most obvious reduction of 64.97km2, while construction land area has the most obvious increase of 34.84km2. The situation is analyzed as related to the national policy of returning farmland to grassland and forest and the growing local environmental awareness. Construction land still shows significant increase in the five years. These data indicate that there is still a lot of room for ecological environment construction in Pisha sandstone area and further efforts are needed.

TABLE V. Transition matrix table of landuse in Pisha Sandstone Area in 2005 - 2010 (unit: km^2)

2010 / 2005	Farmland	Woodland	Grassland	Waters	construction land	Un-utilized land	Total
Farmland	2609.46	43.33	728.34	20.40	16.63	7.88	3426.03
Woodland	33.53	736.79	40.82	1.31	1.03	1.27	814.75
Grassland	679.55	47.73	9921.39	15.81	26.05	32.73	10723.25
Waters	25.63	2.96	15.76	447.14	1.78	0.30	493.55
construction land	5.49	0.34	6.78	1.41	242.33	0.08	256.44
Un-utilized land	7.41	0.81	41.71	0.24	3.45	978.24	1031.85
Total (km^2)	3361.06	831.95	10754.79	486.31	291.27	1020.50	16745.88

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

TABLE VI. Direction Table of Land Transfer in Pisha Sandstone Area in 2005-2010 (unit: km^2)

Land type	New area	Transfer area	Unchanged	Change area
Farmland	751.61	816.58	2609.46	-64.97
Woodland	95.17	77.96	736.79	17.21
Grassland	833.41	801.87	9921.39	31.54
Waters	39.17	46.43	447.14	-7.26
construction land	48.94	14.1	242.33	34.84
Un-utilized land	42.26	53.62	978.24	-11.36

(3) Analysis of landuse transfer in 2010 - 2015

According to the data in TABLE VII and TABLE VIII, in 2010- 2015, there are respectively 2774.46km2, 744.33km2, 9879.07km2, 445.4km2, 265.01km2 and 972.59km2 of farmland, woodland, grassland, waters, urban construction and un-utilized land which remains unchanged in Pisha sandstone area. Where, the relative changes between various landuse types are unobvious, but the area change of construction land is extremely obvious. Other landuse area shows a decreasing trend, and only the construction land shows a sharp increase trend with an increase of 448.58km2. The area of construction land has increased rapidly, indicating that the intensity of urban construction in Pisha sandstone area has been greatly improved in the 5 years, and site selection for construction land is not limited to grassland as the development goals involve various landuse types and expansion to unused land is shown.

TABLE VII. Transition matrix table of landuse in Pisha Sandstone Area in 2010 – 2015 (unit: km^2)

2015 2010	Farmland	Woodland	Grassland	Waters	construction land	Un-utilized land	Total
Farmland	2770.46	26.73	455.58	17.02	87.22	4.05	3361.06
Woodland	24.31	744.33	33.79	2.11	26.82	0.58	831.95
Grassland	485.00	39.91	9879.07	12.88	321.14	16.79	10754.79
Waters	16.04	1.73	11.95	445.40	10.66	0.53	486.31
construction land	11.75	0.78	12.39	1.31	265.01	0.04	291.27
Un-utilized land	2.83	2.24	13.77	0.06	29.01	972.59	1020.50
Total (km^2)	3310.39	815.71	10406.55	478.78	739.86	994.58	16745.88

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

TABLE VIII. Direction Table of Land Transfer in Pisha Sandstone Area in 2010-2015 (unit: km^2)

Land type	New area	Transfer area	Unchanged	Change area
Farmland	539.93	590.6	2770.46	-50.67
Woodland	71.39	87.61	744.33	-16.22
Grassland	527.48	875.72	9879.07	-348.24
Waters	33.38	40.91	445.4	-7.53
constructio n land	474.85	26.27	265.01	448.58
Un-utilized land	21.99	47.91	972.59	-25.92

(4) Analysis of landuse transfer in 2000-2015

According to the data in TABLE IX and TABLE X, in 2000-2015, there are respectively 2,593.67 km2, 618.24 km2, 9643.87 km2, 414.34 km2, 220.92 km2 and 890.02 km2 of farmland, woodland, grassland, waters, construction and un-utilized land which remain unchanged in Pisha sandstone area. Compared with landuse in 2000, farmland, grassland and waters decrease in 2015. Where, grassland has the biggest reduction of 457.13 km2; woodland, construction land and unused land increase to some extent, of which construction land has the biggest increase of 489.36 km2. The total area of increase is equal to the total area of reduction, which is 546.9 km2. The data shows that in the past two decades, the intensity of urban construction in Pisha sandstone area has increased ceaselessly, and the increased construction land is mainly from grassland.

TABLE IX. Transition matrix table of landuse in Pisha Sandstone Area in 2000 - 2015(unit: km^2)

2015 / 2000	Farmland	Woodland	Grassland	Waters	construction land	Un-utilized land	Total
Farmland	2593.67	52.24	603.79	28.92	104.94	14.97	3398.53
Woodland	33.15	618.24	52.68	3.18	32.53	2.64	742.42
Grassland	641.97	121.54	9643.87	27.69	343.90	84.71	10863.67
Waters	22.10	14.13	34.03	414.34	11.90	1.91	498.41
construction land	12.37	0.55	13.10	3.21	220.92	0.34	250.49
Un-utilized land	7.13	9.01	59.08	1.44	25.66	890.02	992.35
Total (km^2)	3310.39	815.71	10406.55	478.78	739.86	994.58	16745.88

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

TABLE X. Direction Table of Land Transfer in Pisha Sandstone Area in 2000-2015 (unit: km^2)

Land type	New area	Transfer area	Unchanged	Change area
Farmland	716.72	804.86	2593.67	-88.14
Woodland	197.47	124.18	618.24	73.29
Grassland	762.68	1219.81	9643.87	-457.13
Waters	64.44	84.07	414.34	-19.63
constructio n land	518.93	29.57	220.92	489.36
Un-utilized land	104.57	102.32	890.02	2.25

2.2.3 Landuse Dynamic Change

(1) Landuse dynamic change index

On the basis of GIS spatial analysis, spatial statistical analysis is usually adopted to quantitatively describe and characterize landuse change characteristics by selecting indexes like intensity, dynamic degree, landuse comprehensive index, etc. Here, the single landuse type dynamic degree (K1) and comprehensive landuse type dynamic degree (K2) are selected.

K_1: is the speed change of a landuse type in a certain area over a period of time; Ua and Ub are the area of a landuse type in the early and late stages of the study respectively; T is the duration of study. If T is year, then K is the annual change rate of a certain landuse type.

K_2 is the overall speed change of all landuse types in a certain area over a period of time; is the area of the i-type landuse type in the initial study; is the absolute value of area of i-class converted to non-i-type landuse in the study period; T is the length of the detection period, like K_1, when T is year, the value of K_2 is the annual change rate of landuse type in a certain area.

In order to calculate the dynamic degree of various land types more accurately, slight modification is made based on the study to further calculate the transfer-in and transfer-out dynamic degree of various landuse types within the research period;

Transfer-out Dynamics Degree = Turn-out Area/Initial Area/Study Period

Transfer-in Dynamics Degree = Turn-in Area/Initial Area/Study Period

The results are shown in the following table:

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

TABLE XI. Landuse dynamic degree from in 2000-2005 (unit: km^2)

	Transfer-out area	Transfer-in area	Transfer-out dynamic degree (%)	Transfer-in dynamic degree(%)	Additional dynamic degree(%)
Farmland	786.58	814.07	4.63	4.79	0.16
Woodland	114.49	186.81	3.08	5.03	1.95
Grassland	966.27	825.84	1.78	1.52	-0.26
Waters	69.59	64.74	2.79	2.60	-0.19
construction land	37.34	43.3	2.98	3.46	0.48
Un-utilized land	66.74	106.25	1.35	2.14	0.80

TABLE XII. Landuse dynamic degree from in 2005-2010 (unit: km^2)

	Transfer-out area	Transfer-in area	Transfer-out dynamic degree (%)	Transfer-in dynamic degree(%)	Additional dynamic degree(%)
Farmland	816.58	751.61	4.77	4.39	-0.38
Woodland	77.96	95.17	1.91	2.34	0.42
Grassland	801.87	833.41	1.50	1.55	0.06
Waters	46.43	39.17	1.88	1.59	-0.29
construction land	14.1	48.94	1.10	3.82	2.72
Un-utilized land	53.62	42.26	1.04	0.82	-0.22

TABLE XIII. Landuse dynamic degree in 2010-2015 (unit: km^2)

	Transfer-out area	Transfer-in area	Transfer-out dynamic degree (%)	Transfer-in dynamic degree(%)	Additional dynamic degree(%)
Farmland	590.6	539.93	3.51	3.21	-0.30
Woodland	87.61	71.39	2.11	1.72	-0.39
Grassland	875.72	527.48	1.63	0.98	-0.65
Waters	40.91	33.38	1.68	1.37	-0.31
construction land	26.27	474.85	1.80	32.61	30.80
Un-utilized land	47.91	21.99	0.94	0.43	-0.51

(2) Features of landuse dynamic change

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

According to the above table, we can see the main features of landuse dynamic change in Pisha sandstone area in 2000-2015:

<1> Additional dynamic degree of construction land is increasing with a large proportion

Seen from the perspective of evolution process, landuse in Pisha sandstone area shows active dynamic change, with different variation characteristics in different periods, mainly shifting from landuse type with low economic utilization benefit to landuse type with higher economic utilization benefit, with prominent manifestation in the increase in Farmland. The additional dynamic degree of construction land in 2000-2005, 2005-2010, 2010-2015 are respectively 0.48%, 2.72%, and 30.80%, showing an upward trend year by year. In particular, in 2010-2015, other types of landuse show a decrease trend with all converted to Farmland, which reflects the continuous development and construction of local real estate and the city.

<2>Additional dynamic degree of water area continues to decrease

Although the water area continues to be transferred in and out, in general, additional dynamic degree of water area decreases in 2000-2005, 2005-2010, 2010-2015. It's possible that climate drought leads to small-area dryness of pond, so water area is converted to other types of landuse.

<3>Additional dynamic degree of other landuse types shows fluctuation change

In 2000-2005, 2005-2010, the dynamic degree of farmland, woodland, grassland and un-utilized land shows fluctuation changes, demonstrating a downward trend in 2010-2015.

<4>Seen from the dynamic degree of various landuse types, the dynamic degree of construction and waters shows linear upward and linear downward trend, but additional dynamic degree of water area changes little, while dynamic degree of construction land changes drastically. Construction land dynamic change is the most important factor affecting landuse change in this area.

2.2.4 Landuse Forecast

The Markov model is a famous mathematical model, which is a powerful tool for describing stochastic phenomena [7, 8]. It is also the simplest type of stochastic process, which plays an important role in all fields of natural and social sciences, but is rarely used for research on landuse change predictions in Pisha sandstone area [9-13].

The Markov process refers to a special random motion process with "no aftereffects". The so-called "no aftereffect" means that the condition distribution of the state of a process at time t ($t > t_0$) is independent of the state of the process before time t_0, when the state of a process (or system) at time t_0 is known.

This is suitable for studying dynamic change of landuse, which is because under certain conditions, the dynamic evolution of landuse shows the nature of Markov process: ① Within a certain area, various landuse types are mutually transformable. ②The process of mutual transformation between landuse types contains many events difficult to be described accurately using functional relationships. The key to using Markov model is to determine the initial transfer probability matrix P for the mutual transformation between landuse types. The

ISSN: 0011-9342
Issue: 10 | Pages: 142 - 156

mathematical expression is generally: P=（Pij）. Where, N is the number of landuse types in the study area, Pij is the probability of conversion from type I to type J from the beginning to the end, which meets the following two conditions: . According to the homogeneous Markov model, the state probability vector P(n) of the object studied by the system at any time can be determined by its initial state probability vector P(n-1) and the transfer probability matrixPij : .

According to the 2000-2015 landuse area transfer matrix in TABLE IX, the Markov one-step transfer probability matrix can be established as shown in TABLE XIV below:

TABLE XIV. Matrix Table of 2000 -2015 Landuse Transfer Probability in Pisha Sandstone Area (unit: km^2)

2015 2000	Farm land	Woodland	Grassland	Waters	construction land	Un-utilized land
Farmland	76.32	1.54	17.77	0.85	3.09	0.44
Woodland	4.47	83.27	7.10	0.43	4.38	0.36
Grassland	5.91	1.12	88.77	0.25	3.17	0.78
Waters	4.43	2.84	6.83	83.13	2.39	0.38
construction land	4.94	0.22	5.23	1.28	88.19	0.14
Un-utilized land	0.72	0.91	5.95	0.15	2.59	89.69

Then, using the number of landuse types in 2015 as the initial vector, with 2000-2015 landuse probability matrix as the initial probability transfer matrix and 15 years as step length, the area of various landuse types in 2030 is predicted as shown in Markov Area Prediction TABLE XV below:

TABLE XV. Markov Area Prediction Table (unit: km^2)

Landuse type	Year 2015(km^2)	Year 2030(km^2)	Change rate (%)
Farmland	3310.39	3242.70	-2.04
Woodland	815.71	870.82	6.76
Grassland	10406.55	10014.68	-3.77
Waters	478.78	467.14	-2.43
construction land	739.86	1157.06	56.39
Un-utilized land	994.58	993.48	-0.11
Total (km^2)	16745.88	16745.88	0.00

It is predicted that by 2030, the area of farmland, woodland, grassland, waters, construction land and un-utilized land in Pisha sandstone area will be 3242.70km^2, 870.82 km^2, 10014.68 km^2, 467.14 km^2, 1157.06 km^2 and 993.48 km^2, respectively. The urban construction land will still show a fast-rising trend, with an increase of 56.39% over 2015.

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III. CONCLUSION AND DISCUSSION

The landuse area was analyzed by remote sensing interpretation, the transfer matrix of landuse was made to analyze the spatial structure and study the dynamic change degree. Moreover, Markov model was used for landuse prediction. Through the analysis, the conclusion is as follows:

(1) In 2000-2015, the total landuse area of Pisha sandstone area in Inner Mongolia remained unchanged, but the various landuse types changed greatly. The main trend of change is the obvious increase of construction land, whose increase rate shows sharp rise. In the future development, the government needs to strengthen grassland protection, strengthen the control on the expansion of construction land, strive to improve the intensive utilization level of construction land, and alleviate the constraints of land on social and economic development.

(2) In 2000-2015, there were 2,593.67 km^2, 618.24 km^2, 9643.87 km^2, 414.34 km^2, 220.92 km^2 and 890.02 km^2 of farmland, woodland, grassland, waters, urban construction and un-utililzed land which remained unchanged in Pisha sandstone area. Compared with 2000, landuse of farmland, grassland, waters decreased in 2015. Where, grassland had the biggest reduction of 457.13 km^2. Woodland, construction and un-utilized land increased to some extent, of which construction land had the biggest increase of 489.36 km^2. The total area increased is equal to the total area of reduction, which is 546.9 km^2. The data shows that in the past two decades, the intensity of urban construction in Pisha sandstone area has raised steadily, and the increased construction land is mainly from grassland.

(3) Dynamic degree of construction land and water area showed a linear upward and linear downward trend, but water area had small additional dynamic degree, while construction land changed drastically in dynamic change. The dynamic change of construction is the most important factor affecting landuse change in this area.

(4)If the change rate of landuse in 2000-2015 is maintained, by 2030, the area of farmland, woodland, grassland, waters, construction and un-utilized land in Pisha sandstone area will be respectively 3242.70km^2, 870.82km^2, 10014.68km^2, 467.14km2, 1157.06 km^2, 993.48 km^2. Compared with 2015, the area of farmland, grassland, waters and un-utilized land will continue to decrease in 2030, and the area of woodland and urban construction land will continue to increase, especially construction land whose increase rate will reach 56.39%.

Markov model is used to predict the dynamic changes of landuse, which only serves as theoretical analysis, and there is need to predict the change of land based on the actual situation. In future research, advanced means like satellite remote sensing monitoring should be used to regularly monitor the changes in the status of landuse in the local area, timely grasp the changes in landuse status, effectively prevent illegal land abuse, ensure the rational and effective use of each inch of land, and provide a basis for environmental protection and local landuse planning target adjustment.

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