LANDSCAPE RESTORATION REGIONALIZATION FOR RESOURCE-EXHAUSTED COAL MINE AREAS BASED ON GIS

Linlin Wang[2] and Zhenqi Hu

Abstract: Landscape restoration regionalization is to ascertain the restoration unit from landscape point based on the theory of landscape ecology, ecological economy and some other subjects. This paper discussed the aim and meaning of landscape restoration regionalization, ascertained the process for it. Then taking the abandoned mining areas of MTG of Beijing as an example, this paper built the index system of landscape restoration regionalization on the basis of existing research and on-the-spot investigation, which contains 8 indexes, and 11 factors. Based on GIS, every index was analyzed, partitioned the action scope by its own information and the corresponding criterion. Then according to the service function of research area, the suitable degree of any action scope of each index was determined by Delphi, and valued to 0-10. By using of GIS and database techniques, the spatial data and attribute data were managed, by overlapped the natural indexes and social economy indexes, the multi factors were analyzed synthetically, then by the fuzzy comprehensive assessment model and the principle of maximum degree of membership, the suitable degree of each research unit was calculated, and the suitable using of each unit was confirmed. In this research, there are three kinds of landscapes were confirmed. With the results of landscape suitable assessment and based on the land use, the landscape units and structure to be restored was determined, then the landscape restoration plan were made. In this paper, 16 landscape restoration regions were classified, and the restoration suitability and land-use for each unit were also determined.

Additional Key words: resource-exhausted coal mining area, landscape restoration regionalization, GIS

---

[1] Poster was presented at the 2009 National Meeting of the American Society of Mining and Reclamation, Billings, MT, ***Revitalizing the Environment: Proven Solutions and Innovative Approaches*** May 30 – June 5, 2009. R.I. Barnhisel (Ed.) Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

2 Linlin Wang City College, Capital University of Economics and Business, Beijing, 100070, China, Zhenqi Hu. Institute of Land Reclamation & Ecological Reconstruction, China, University of Mining and Technology (Beijing), Beijing, 100083 China.

Proceedings America Society of Mining and Reclamation, 2009 pp 1512-1519
DOI: 10.21000/JASMR09011512
http://dx.doi.org/10.21000/JASMR09011512

Introduction

The unrestrained exploitation of coal resources lead to severe environmental problems in resource-exhausted areas in China. With the population growing and resources exhausting, ecological restoration is coming to be a necessary approach to harmonize the economy development and the population growing, the resources mining and the environment protection.

The past ecological restoration, both in research and practice, focused on small restoration engineering. But in resource-exhausted areas, the whole service function will be changed, so its ecological restoration is not a single engineering but an integrated harmonization. In order to achieve this purpose, landscape restoration regionalization (LRR) is necessary. LRR is mainly to ascertain the restoration unit from landscape point based on the theory of landscape ecology, ecological economy and some other subjects actually. The abandoned mining area is the area that environmental damaged severely, so the landscape in these areas should be reconstructed on order to maintain its function, should take the properties of natural resources and local social economy into account. For resources exhausted coal mines, the landscape restoration regionalization is special that should to wipe off the damaged landscape and restore the landscape structure

Study area

Location and natural condition

Mentougou district (MTG) is in the west of Beijing city, just 40km from Beijing. This area is mostly a mountainous area, which contributed 98.5% area of the total MTG. There are more than 160 hills which elevation more than 1500m. So it's very important to protect the environment of Beijing.

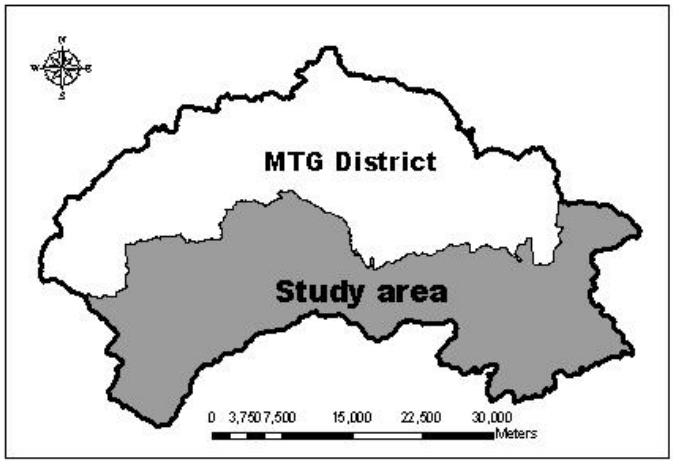

Figure1 Map of the coal region in MTG District.

In Fig. 1, the area inner the thick line is the whole MTG district of Beijing. The gray area is the coal resource coverage and influenced areas by coal mining, namely the study area of this research. The area of this research area is 726.7km^2, account for 49.9% of total MTG.

Coal resource mining and Eco-environment damage

Coal mining in MTG has a long history, which began from about 1,000 years ago. The coal resource covers more than 700 km^2, accounting for half of total MTG. This mining area is one of the five biggest anthracite producing areas in China, and also is an important energy base of Beijing. After long-time mining activities, the geological structure and eco-environment of this area was disturbed severely. There are 257 coal waste piles, which coverage 183.5hm^2, 425 collapse pits, and 774 cracks. In addition, vegetation damage, soil erosion, unreasonable land using is also very severe.

With the coal resources beginning to be depleted, MTG will change its function from "mining areas" to "eco-environment service areas". So the ecological restoration becomes a very urgent and necessary task in MTG.

Landscape restoration regionalization of study area

The process of landscape restoration regionalization

LRR is a process to plan the suitable spatial structure for natural and ecological factors based on the landscape damage and natural conditions. In order to carry out this process, the suitable landscape functions need to be ascertained, then determine the extent of landscape damage due to coal mining. Then based on the current situation, and plans are needed to restore the landscape. Restoration means, evaluation of the aspect and using appropriate restoration techniques which will give at least one suitable landscape structure which meets natural, social and economical conditions.

So the process of LRR is a little change on the basis of the normal process of landscape planning. The steps and methods can be seen as Fig. 2.

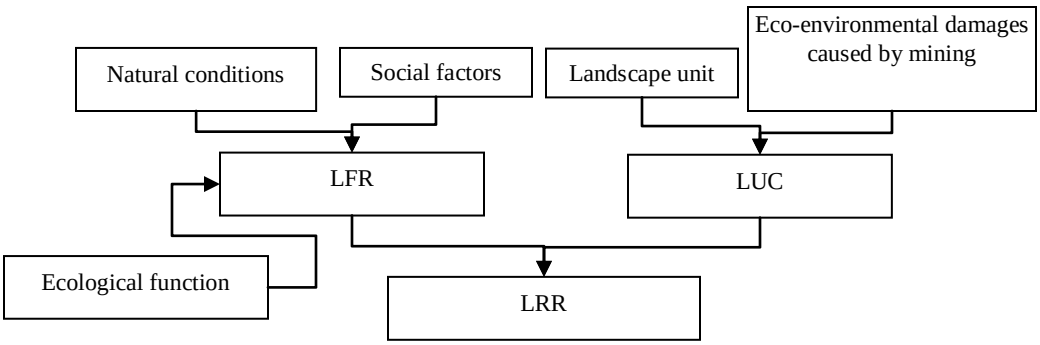

Figure 2 The basic process of LRR

The process of LRR is similar to the normal process of landscape planning that integrate "up to down" and "bottom up" process together (LI Zhengguo, etc. 2006). The process of landscape functions regionalization (LFR) is to intersect the all regions of ecological function, natural conditions and social factors. Each of the factors should be partitioned by others, so this is "up to down" process which partition the big region to many small areas. Opposite to this process, the process of landscape unit classification (LUC) is clustering the small landscape units to necessary classes, which is "bottom up" process. Then based on LFR and LUC, two spatial results of them can be overlapped by GIS. By the spatial analysis, the area that the landscape class is not fit to the landscape function can be found, and such areas were the area that should be restored.

Landscape function regionalization

Index system LFR should reflect the natural conditions and the social-economical demand of study area simultaneously. MTG is a mountain area, so altitude, slope, aspect, climate, soil characters, etc., should be contained in the index system. For demand, because Beijing government took MTG as the "ecological service area for Beijing", modern service industry and tourism industry should become the main industries of MTG. So the location, traffic advantage, tourism resources and diathesis of local people are the direct relational factors to the social-economical demand. Therefore, the index system of LFR can be seen as Table 1.

Evaluate the value of each index According to the service function of MTG, the main industry types will be ecological agriculture, city industry and ecological tourism. At first, every index should be assessed by its own information and the corresponding criterion. For example, in order to assess Geological stability, the character of coal mine roof, the depth of mined area times of repeated exploitation, angel of coal bed, the geological complexity, the types and thickness of the

coverage on the coal bed and some other factors should be considered, by GIS and other methods, risk of collapse can be confirmed, which can reflect the geological stability in coal mine areas. Altitude, slope, aspect, air temperature, etc. , the all indexes will be classified by corresponding method. Then according to the service function and industry type, the suitable degree of any action scope of each index was ascertained by Delphi, and evaluated 0-10(SHI Xiao-xue, etc., 2006).

Table1. The value of each factor for different purpose in landscape function regionalization

Indexes of LFR		Classification	Value			
			Ecological agriculture	Forest	City industry	Ecological tourism
Geological stability	Risk of collapse	low	10	10	10	10
		medium	7	8	4	3
		high	3	5	1	1
Terrain conditions	Altitude (m)	0-500	10	6	10	-
		501-1000	7	9	6	-
		1001-1500	6	8	4	-
		1501-1894	5	7	2	-
	Slope (°)	<7	10	4	10	-
		8-15	8	5	7	-
		16-25	5	8	3	-
		26-35	1	5	1	-
		>35	0	3	0	-
	Aspect (°)	0	10	4	10	-
		157.5-247.5	10	4	10	-
		247.5～292.5，112.5～157.5	7	8	9	-
		67.5～112.5，292.5～337.5	3	6	8	-
		337.5～22.5，22.5～67.5	0	3	1	-
Climates	Air temperature(°) (cumulative temperature above 0°)	≥4500	10	4	-	-
		3000-4500	7	7	-	-
		<3000	2	5	-	-
	Precipitation （mm）	≥550	8	8	-	-
		400-550	5	6	-	-
		<400	2	3	-	-
Soils	Soil types	Cultivated cinnamon soil	10	5	-	-
		Cinnamon soil	5	7	-	-
		Sandwich soil	6	7	-	-
		Generic cultivated soil	1	3	-	-
Hydrographical conditions	Distance from reservoir or river(m)	≤500	10	5	5	10
		500-1000	7	5	7	7
		≥1000	3	5	5	5
Traffic	Distance from main highway or railway(m)	≤1000	10	-	10	10
		1000-2000	6	-	6	6
		≥2000	2	-	2	2
Humanity resources	Distance from travel industry sites(m)	≤3000	10	-	-	10
		3000-6000	4	-	-	6
		≥6000	0	-	-	1
	Local people's educational level	high	10	-	10	10
		medium	7	-	7	6
		low	3	-	3	2

（ "-"means the index is low relativity to the industry type）

Results of LFR Based on GIS, the value of each factor was put into the attribute table, on the basis of raster data, the suitability for different industry type of each unit was calculated. By the principle of maximum degree of membership, the most suitable industry type of the study unit was confirmed. In this paper, the scope of ecological agriculture, forest, city industry and ecological tourism was confirmed, also the areas that suitable to all the types. The map of each area can be seen from Fig. 3.

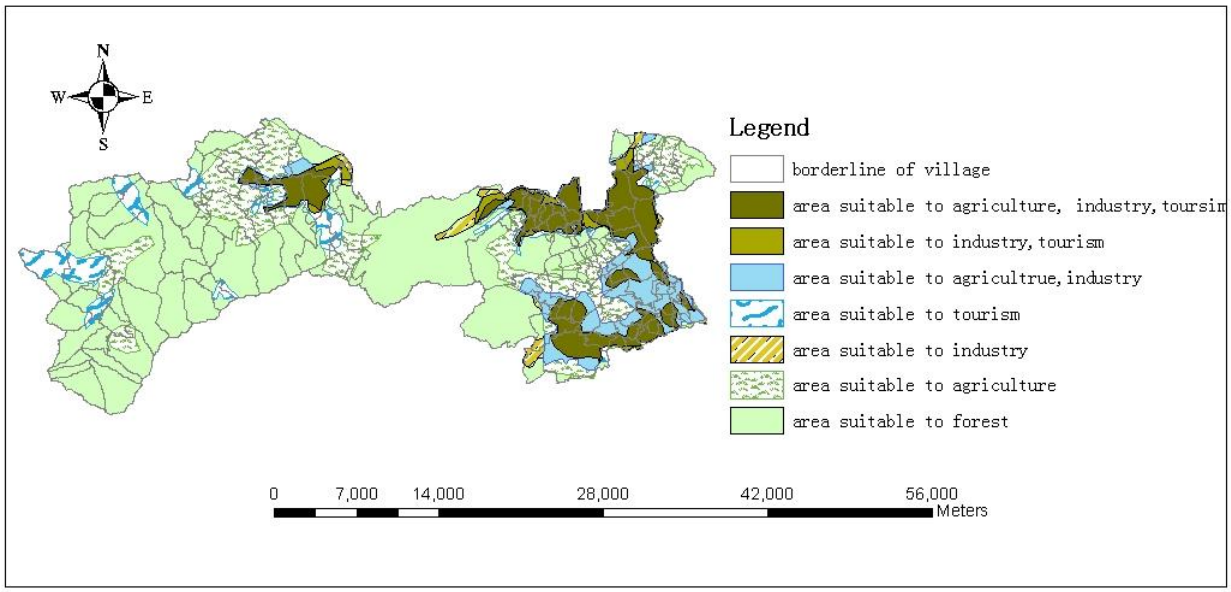

Figure 3 The regionalization of the landscape function

Landscape unit classification LFR regionalized the study area based on the suitability to industry type, so the restoration orientation was ascertained. But because the landscape of mine area disturbed by mining, the problems in landscape actuality were needed to be found too. This paper based on the land use actuality and eco-environmental damages, partitioned the total study area as 11 types, as Fig.4.

LFR regionalized the study area based on the suitability to industry type, so the restoration orientation was ascertained. But because the landscape of mine area disturbed by mining, the problems in landscape actuality were needed to be found too. This paper based on the land use actuality and eco-environmental damages, partitioned the total study area as 11 types, as Fig.4.

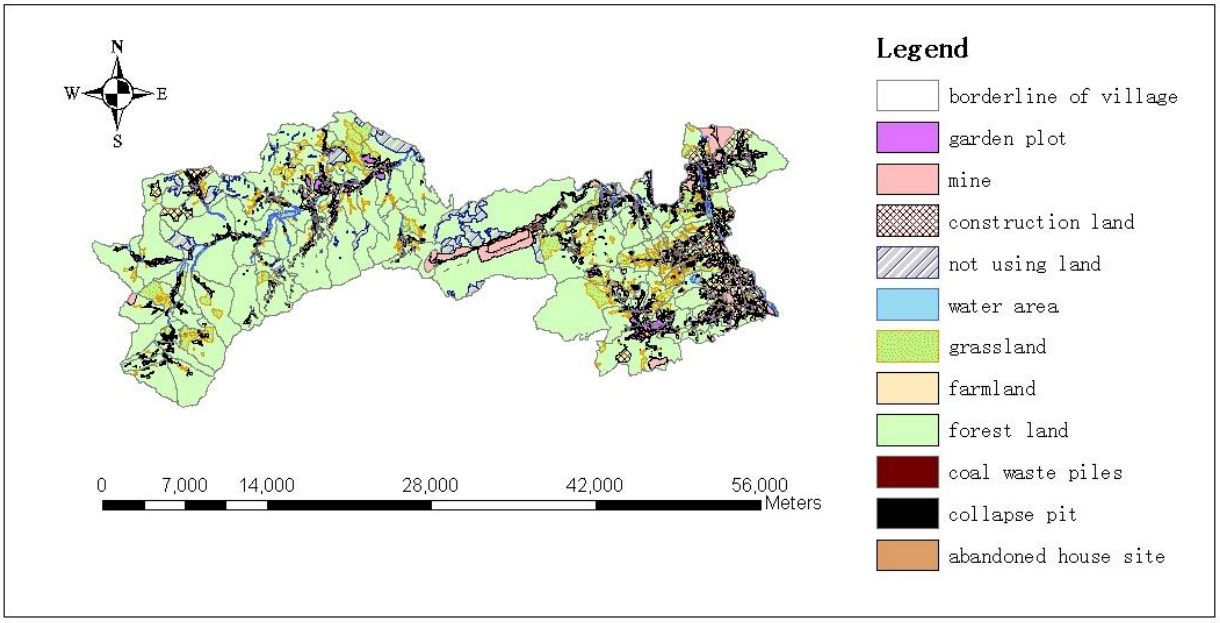

Figure 4 The classification of the landscape actuality units

Landscape restoration regionalization After the LFR and LUC, the restoration orientation and problems need to be restored were all ascertained, so the landscape restoration can be planned. By integrating the results scope of LFR and LUC, the restoration units were partitioned; and by analyzing the gap of landscape actuality and landscape function, the restoration methods and techniques were confirmed. The results of LRR is useful to construct a harmonious landscape structure, useful to the restoration engineering carry out and management because of the clear borderline of restoration units, eventually promote the district ecological restoration.

This paper confirmed 16 restoration regions (Fig.5) on the basis of upper research and administrative borderline. Every unit was named by place name and ecological restoration orientation or landscape function, the location and restoration means and techniques of each unit were showed. And based the damaged degree, the restore difficulty, restore sequence and restore fund of each project were determined. (Because of the limit of paper space, the detailed information about the 16 regions was omitted.)

Conclusions

This paper analyzed the process of LRR, is a process that integrated the LFR and LUC. Then took MTG as example, that process was carried out, 16 restoration projects were partitioned at last. In the process of LRR, the natural, social and economical information can be all considered.

And because the process of LRR took the natural, social, economical factors and the damages because of mining into account together, not only the areas that need to be restored of MTG were found, but also the restoration orientation, the suitable restoration means and techniques can be chosen too. It can be shown from the example in this paper, based on GIS, the process of LRR is easily to carry into execution. So this paper can offer some useful reference to resource-exhausted mine areas restoration. Certainly, there maybe have some problems and shortcomings in this paper, welcome criticism and communion.

References:

Zheng Du, Fu Xiaofeng. (1999). A Preliminary Study on Issues of Integrated Geographical Regionalization. SCIENTIA GEOGRAPHICA SINICA, 19(3):193-197. (Chinese)

LI Zhengguo, WANG Yanglin, Chang Hsiaofei, WU Jiansheng. (2006). Principles and Systems of Landscape Ecological Regionalization. PROGRESS IN GEOGRAPHY, 25(5):10-20. (Chinese)

SHI Xiao-xue,MA Wei-chun,PU Jing-jiao,ZHANG Ha.(2006) GIS & RS-based Ecological Suitability Assessment for Land Development and Landscape Structure Analysis : A Case Study of Jindong Eco-industrial Park, Sanming City. Journal of Fudan University (Natural Science), 45(3): 367-374. (Chinese)

Wang Ying-gang, Feng Zhi-yu, Cheng Wu-liang(2000). The fuzzy multiple comprehensive assessment of environmental quality of cities. Environmental Protection Science,.5:85~87. (Chinese)

Helen Bennion,T. John Hilton,Mike Hughes(2005). The use of a GIS-based inventory to provide a national assessment of standing waters at risk from eutrophication in Great Britain. Science of the Total Environment 344: 259– 273. http://dx.doi.org/10.1016/j.scitotenv.2005.02.016

QIAN Minggao，MIU Xiexing，XU Jialin(2007). Green mining of coal resources harmonizing with environment. Journal