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Based on Digital Elevation Model (DEM) for Farmland Landscape Pattern

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Abstract

Taking Gongyi city as a study area and by using the ArcGIS software, this paper analyzed the characteristics of farmland landscape patterns at the five slope gradients by Digital Elevation Model（DEM）, and explored the human disturbance on farmlands. The results indicated that the distribution of farmland landscape elements differed obviously with slope gradients, the main farmland landscape elements was dryland and the irrigable land, and dryland inter-planted with fruit trees distributed in. The irrigable land distributed widely in the upland at <15°, the area of patches was large. The dryland had a relatively lower disturbance both in intensity and in frequency and lower utilization efficiency, which mainly distributed at 2°~15°. The effective area of patches of dryland inter-planted with fruit trees was low, and was gradually transformed into orchard. Those farmland landscape at 2°~6° and 6°~15° were the two major distributions of slope gradients, and were the key for realizing sustainable use of farmland. Human disturbance and dependence were lower at >15°, and the farmland landscape elements were gradually transformed into natural ecological elements, which would benefit the eco-environment of the study area.

Key Words*: GIS, DEM, farmland landscape; slope; Gongyi city*

1 Introduction

Farmland is the most basic material basis of human survival and development. It not only has the function of providing agricultural products to ensure food security for human, but also with a more important social value and ecological value to sustain human beings and development relied on environment[1]. In recent years, with the rapid economic development, the speeding up industrialization and urbanization, dramatic changes have taken place in the farmland landscape. Accurate identify the disturbances and strength of human activities on farmland, has become an important research topic in the sustainable utilization and farmland protection[2].

Human disturbance on farmland subjects to the social, economic, climate, terrain and many other factors, but in terms of the local scale, the terrain conditions, especially the land slope gradient conditions are the main factors[3]. Ground slope becomes a objective condition of restrict human land use mode and the choice of management practices. thus the formation of the farmland landscape pattern also shows the frequency and intensity of human disturbance on cultivated land realistic scenario[4]. By quantifying calculate and qualitative analysis to landscape index, not only can find that the farmland landscape mosaic has potential significance of regularity, but also to better explain and understand the farmland landscape function, which lays a fundation for further study of farmland landscape function and dynamic[5].Currently, with the aid of the method of landscape

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ecology research on the characteristics of the landscape pattern of land resources have many articles[6-11], to sum up, mainly from the improvements and the introduction of new techniques in research methods, especially the development of GIS and RS technology, making it possible to extract terrain slope factors rapidly, promoted the farmland landscape research rapidly[3]. At this point, Gongyi City is still blank in research on farmland landscape through the introduction of slope factors. So this article taking Gongyi City as a study area analyzed the characteristics of farmland landscape patterns at different slope gradients, by using the ArcGIS technology and landscape pattern analysis software, providing a theoretical reference for the sustainable use of cultivated area and delineation basic farmland protection areas.

2. The Study Area and Research Methods

2.1. Overview of Study Area

Gongyi City locates in the central of Henan Province, the north hillside of Songshan, under the governed of Zhengzhou City, adjacent to Xing Yang on the east, bordering YanShi westward and northern in The Yellow River (34°31'~34°52'N, 112°49'~113°17'E). In The terrain, hills in the middle and south high north. On both sides of the Yiluo River are floodplain belong to the hilly area of the mountains. Total area of 1041km2 and the city governd15 towns,5 sub-district offices,2 park management committees in whole. It is a continental warm temperate monsoon climate, four distinct seasons with adequate light, the average temperature is 14.8 per year and the average annual precipitation is 597.2mm. What's more, the annual frost-free period about 234 days and altitude of 104 ~ 1487m.The soil type varied, large differences in soil fertility, mainly have tide soil, brown soil and brown soil three soil types.

2.2. Data Sources and Processing

The Digital Terrain Model is a digital representation of the natural information of terrain surface morphology and a digital description of features with spatial location and terrain property. When the terrain property is elevation, we call this kind of digital terrain model is Digital Elevation Model (Digital Elevation Model, DEM). The changes of the surface elevation of a region can be expressed in many ways, surface, point, line or image which are defined by a mathematical definition can be used to represent the DEM.

The main data sources we selected are 1:1.8 ten thousand of the Current land use mapstatus in Gongyi City, 2011. (offered by Gongyi City Land and Resources Bureau)Gongyi City statistical yearbook of 2012, 30 meters resolution digital elevation map. Based on "land use classification status of" national standards of quality supervision, inspection and quarantine and the standardization administration of china in 2007 jointly issued, combined with the actual situation of Gongyi City, the farmland were divided into two class of irrigated land and dryland, dryland subdivided into general dryland and dryland inter-planted with fruit trees.

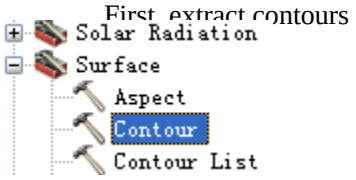
Using ArcGIS10.0, Fragstats4.0 software to process data. Firstly, analysis the correlation with the slope of the spatial distribution of farmland, using ArcGIS software to devided slope into 0°~2°, 2°~6°, 6°~15°, 15°~25° and > 25° these five slope gradients, generate slope gradients map. Then overlay three types of landscape patttern map generated by farmland landscape elements and slope gradients map, generate the map of farmland landscape pattern with slope gradients. And then, one by one input landscape pattern analysis to the software Fragstats4.0, calculated the farmland landscape indices under different slope and analysis of farmland landscape pattern and its evolution. This paper analyzes the characteristics of structural changes in landscape, using two major types of area length, and shape, *etc*., selects the number of patches, total patch area, average patch area, standard deviation of patch area, the largest patch index, patch density,

The coefficient of variation of plaque area and fractal dimension values**,** these eight landscape pattern indexes. The calculation results are shown in Table 1.

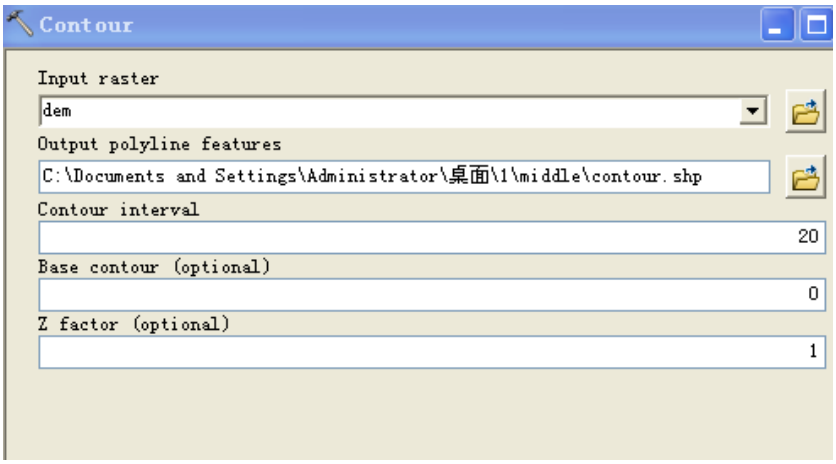
Table 1. Statistical Results of Landscape Metrics on Landscape Element Under Different Gradients

Farmland types	landscape pattern indexes	Slope gradient				
		0°~2°	2°~6°	6°~15°	15°~25°	>25°
Irrigable land	The total area of patches(hm^2)	3825.09	8187.48	2039.76	125.01	25.02
	Number of patches(per)	3084	1628	1593	171	34
	Patch density (per/km^2)	6.5344	3.4494	3.3752	0.3623	0.072
	The largest patch index	0.1871	2.1392	0.1013	0.0124	0.0105
	The average patch area(hm^2)	1.2403	5.0292	1.2805	0.7311	0.7359
	Patch area standard deviation	3.7524	37.0124	2.6297	0.973	0.9682
	Patch area coefficient of variation(%)	302.5422	735.9559	205.3746	133.1021	131.5721
	Fractal dimension	1.4222	1.508	1.4091	1.4734	1.385
General dryland	The total area of patches(hm^2)	1741.14	9330.48	17100.63	3790.53	326.34
	Number of patches(per)	4985	7715	6887	4343	644
	Patch density(per/km^2)	10.5622	16.3465	14.5921	9.2019	1.3645
	The largest patch index	0.0479	0.8577	0.9685	0.0484	0.0166
	The average patch area(hm^2)	0.3493	1.2094	2.483	0.8728	0.5067
	Patch area standard deviation	0.8007	6.5285	12.3464	1.5242	0.7438
	Patch area coefficient of variation(%)	229.249	539.8126	497.2327	174.6343	146.7853
	Fractal dimension	1.4094	1.5049	1.486	1.4161	1.3746
	The total area of patches(hm^2)	90.72	304.29	260.64	43.92	5.67
	Number of patches(per)	264	462	321	105	11
	Patch density(per/km^2)	0.5594	0.9789	0.6801	0.2225	0.0233
	The largest patch index	0.0175	0.033	0.0439	0.0057	0.0055
	The average patch area((hm^2)	0.3436	0.6586	0.812	0.4183	0.5155
	Patch area standard deviation	0.6898	1.4218	1.7404	0.5308	0.7282
	Patch area coefficient of variation(%)	200.7285	215.8749	214.3404	126.8931	141.2788
	Fractal dimension	1.395	1.4062	1.4383	1.3724	1.2123

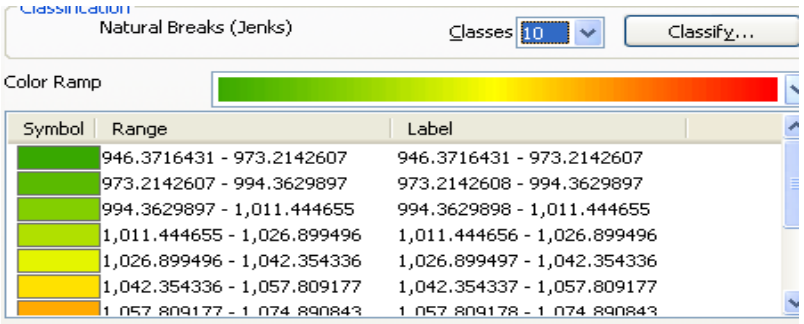
Using hypsometric method of ArcGIS for achieving DEM visual analysis and generating three-dimensional contours, three-dimensional wireframe perspective, three-dimensional terrain surface model. Using hypsometric method in this paper:



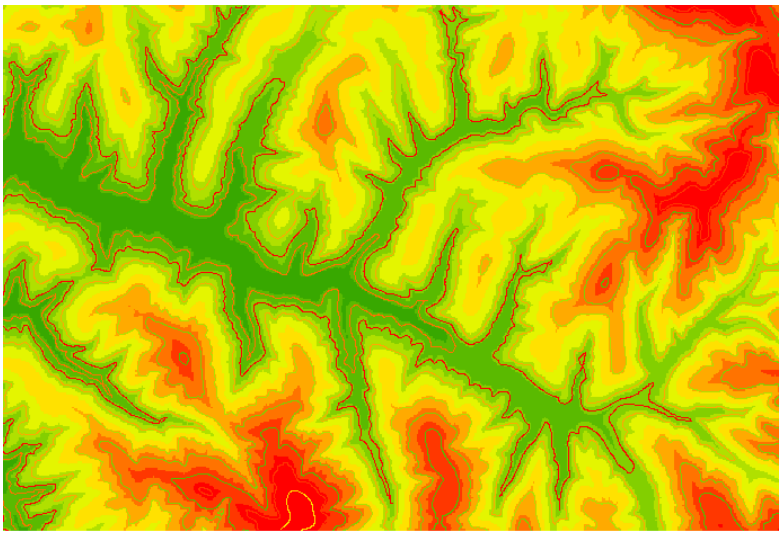
Tools: In the spatial analysis, setting parameters:



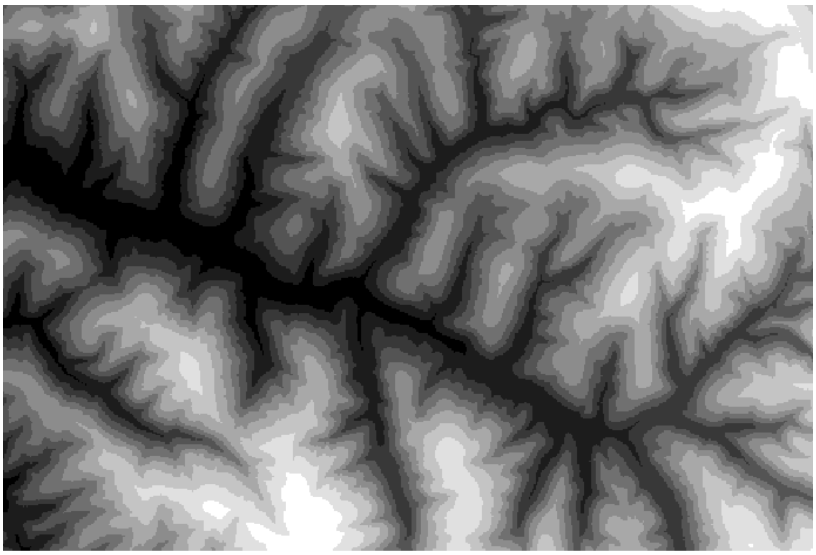
Second, Hypsometric Tint. Hypsometric Tint of DEM.



Generated Figure:

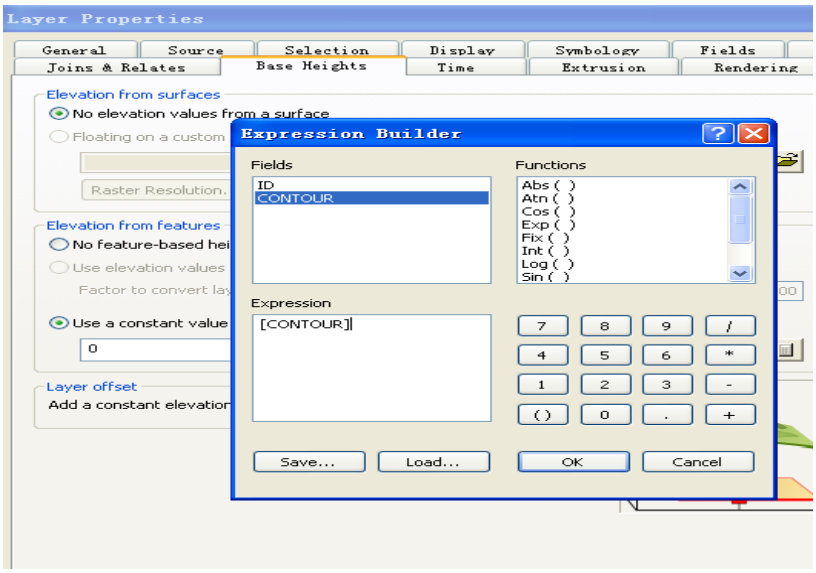


Next: The Gray Image Based on Elevation Data.



Establish three-dimensional contour.

Open ARCSCENE, add counter, set in the properties of the contour:



Finally, Generate Image.

3 Analysis of Landscape Pattern

3.1. Farmland use Structure and Landscape Distribution Patterns

Table 1 told us, the dryland was the main farmland use types in gongyi city generally, an area about 32289.12hm^2, accounting for 68.41% in the total area farmland, widely distributed. Followed by irrigable land area of 14202.36hm^2, accounting for 30.09% in the total area farmland, mainly concentrated in flood plain of Yiluo on both sides, the Yellow River irrigation area and southwestern plain area, dryland inter-planted with fruit trees, an area of 705.24hm^2, mainly concentrated in the low hilly area, northwest of Gongyi City and the left bank of Yiluo low hilly area and were lightly scattered in the southwestern plains area.

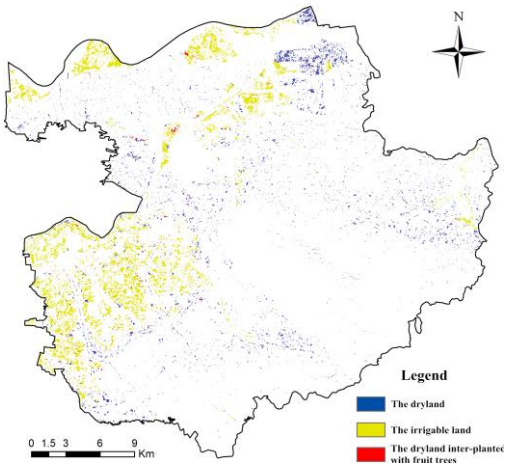


Figure 1. Distribution of Farmland Types

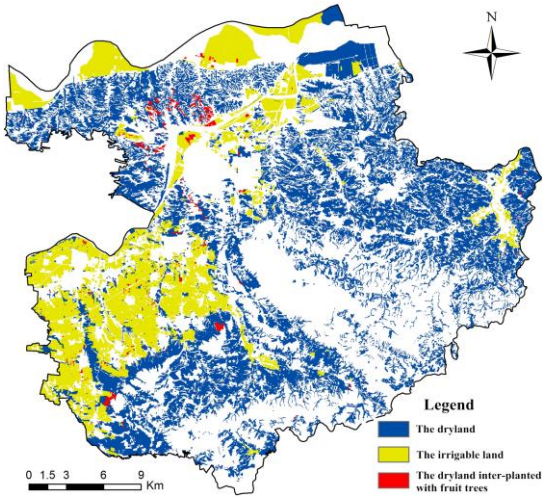


Figure 2. Farmland Landscape at 0°～2°

3.2. Same Slope Gradient within the Different Farmland Landscape Types of Landscape Pattern

The Table 1 shows that 0° ~ 2° slope cultivated land within a total area of 5656.95 hm^2, Accounting for 11.96% of the total area of farmland. Among them, The number of irrigable land landscape patches are 3084, total patches area 3825.09hm^2 (Accounting for 67.62% of total farmland in the slope).Thus, the slope gradients farmland landscape mainly in irrigated landscape, concentrated in the river valleys and plains, as shown in Figure 2.The coefficient of variation of plaque area and fractal dimension values displayed, irrigable land> general dryland> dryland inter-planted with fruit trees, shows irrigable land Landscape elements patch shape is complexity, regularity is not strong, level of human interference is minimum; Dryland inter-planted with fruit trees landscape elements patch geometry tends to be simple, almost is square or round, the degree of human disturbance is the largest, embedded distribute in the irrigable land landscape elements, have a large arbitrariness when turn into a fruit garden; Generally, dryland scattered in the study area of low hilly land (in addition to the south-east), the degree of human disturbance in middle level. According to the proportion of landscape in area, in a relative sense given the landscape contribution rate of each type, the contribution of irrigable land landscape element is the largest in this slope gradient, the structure and stability of landscape features or not will be directly related to the surface material flow, energy redistribution occurs and biological diffusion and migration ,a variety of ecological processes occurs at the same time, become the focus of the work sustainable use of farmland in the slope gradient.

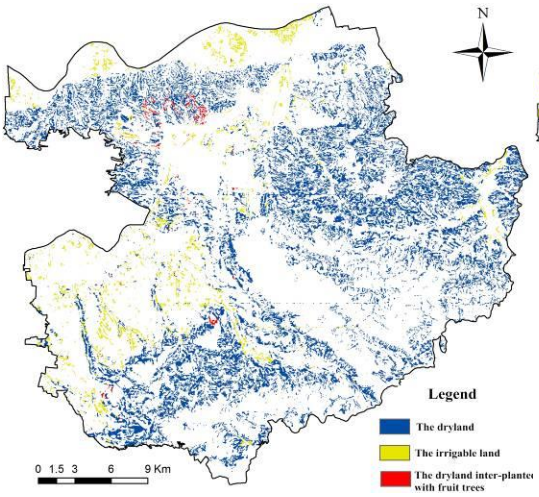


Figure 3. Farmland Landscape at 2°～6°

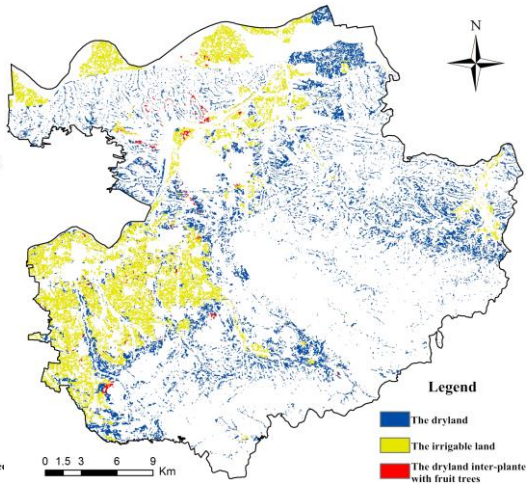


Figure 4. Farmland Landscape at 6°～15°

Within 2° ~ 6° slope farmland landscape area of 17822.25 hm^2, 37.76% of the total area of farmland in the study area, is the second mainly cultivated land slope gradient. Irrigable land and general dryland patch area of 8187.48 hm^2, 9330.48 hm2, respectively, become the main farmland landscape in this slope gradient(chart 3), but the difference between both number and patch density is larger, general dryland patch number is more than irrigable land. In addition, looking from distribution form, irrigable land present continuous distribution, general dryland more scattered, dryland inter-planted with fruit trees set in the west in the study area. Similar to the characteristics of landscape pattern indexes. According to the patch area's variation coefficient and fractal dimension index value, irrigable land and general dryland differs little in the two elements, higher than dryland inter-planted with fruit trees, landscape elements Indicates that the former two landscape patch elements are similar in the geometry complexity and irregularity, the degree of interference are lower by human, lower in patch effective area and cultivated land consolidation can be implemented to increase the effective area of farmland.

The attached Figure 4 and Table 1 shows that within 6° ~ 15° slope of various landscape elements distribution are unequal, the quantity in patches are different, high in landscape heterogeneity. General dryland landscape elements patch area is the largest and the number is the most, far more than other two kinds of farmland landscape, becomes the main farmland landscape type, in this slope gradient, the ecological processes and the degree of interference which it occurs will directly affect other landscape elements. From patch area standard deviation and coefficient of variation of patch area. The general dryland landscape elements performance is the largest, the general performance of the largest dryland landscape elements, 12.35 and 497.23%, respectively, its patch size has significant difference. The fractal dimension value displays that general dryland > intercropping fruit tree dry land > irrigable land > 1.4, patch geometry is more complex, the edge curve smoothing, low in effective patch area and lower in human disturbance. On the other hand, to study its distribution form, scattered of irrigable land, dryland inter-planted with fruit trees distributed in general dryland element in the northwest, general dryland landscape elements are concentrated in towns and villages around the hilly area, in order to carry out land consolidation to increase the effective area of farmland and improve efficiency and create favorable conditions for farmland. In addition, the slope gradient farmland landscape area is 19401.03hm^2, accounting for nearly 41.11% of the total area farmland in the study area, is the main distribution slope gradient of farmland, most strongly affected by human activities. The spatial pattern of landscape

elements, is the most objective and most real reflection in the study area of farmland ecosystem structure and function changed, is a key area of sustainable land use.

15° ~ 25° slope farmland landscape area is relatively small, about 3959.46 hm^2, including general dryland and irrigable land and dryland inter-planted with fruit trees area accounted for 95.73%, 3.16% and 1.11%, respectively, the main elements is dry landscape in general (attached Figure 5 and Table 1). Three kinds of farmland landscape are scattered distribution, which generally arid scattered distribution in the edge of the mountain near the residential areas. Points, according to the dimension numerical general dry land > irrigable land > dryland inter-planted with fruit trees dryland, the patch geometry is relatively complex, human disturbance is lower, can proper implementation of land consolidation project in order to increase effective farmland, is conducive to the protection of the ecological environment.

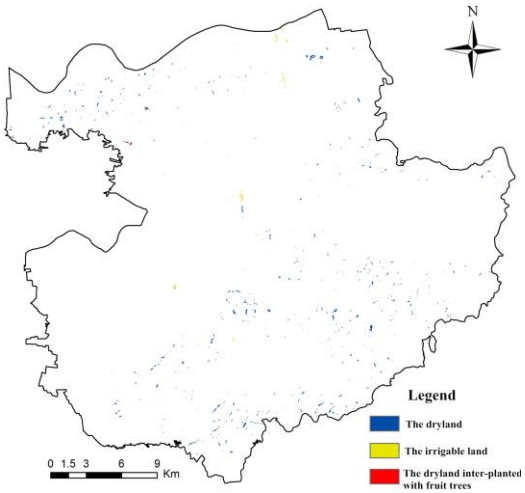


Figure 5. Farmland Landscape at 15°～25°

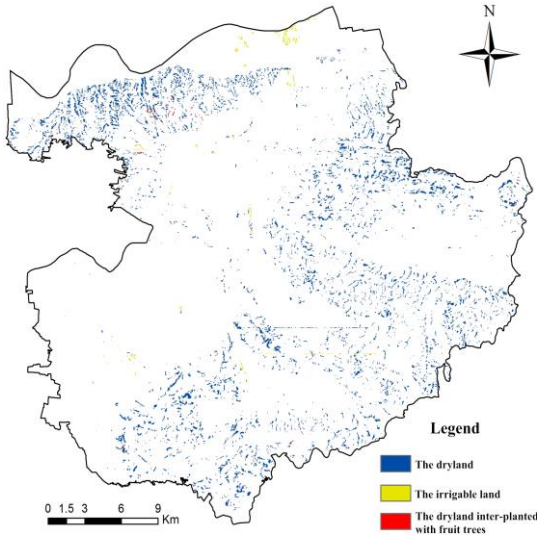


Figure 6. Farmland Landscape at >25°

Within > 25° slope, farmland landscape in a total area of 375.03 $hm^{2,}$ accounts for only 0.76% of the total farmland area. Farmland landscape is still dominant in general patch number and area of dry land (Figure 6). The fractal dimension value display, according to three kinds of the value of the farmland landscape elements at around 1.3, dryland inter-planted with fruit trees value is only 1.2123, shows geometry of patch of three farmland landscape elements tend to simple, in the slope gradient. Human disturbance degree is bigger, so it is necessary to take such as returning farmland to forest and grass measures, strengthen the protection of the ecological environment in the slope.

4. Conclusion and Discussion

In this study, analyzed farmland landscape pattern characteristics under different slope in Gongyi City, using GIS technology and landscape pattern analysis method. The main draw the following conclusions:

(1) The farmland landscape types is mainly distributed in 0° ~ 2° , 2° ~ 6° and 6° ~ 15° slope, the proportion of the total cultivated area was 11.96%, 37.76% and 41.11%. The most sensitive in farmland landscape change, most strongly affected by human disturbance, should be used as a key areas in the sustainable use and protection of farmland.

(2) The overall displayed the farmland landscape features mainly in irrigable land and general dryland landscape, dryland inter-planted with fruit trees distributed in two big landscape elements. Irrigable land is mainly distributed in the < 15° slope condition, large patch and contiguous distribution, water, terrain and labor factors become the major factor affecting the labor factor in the study area of irrigable land landscape pattern; General dryland concentrated in 2° ~ 6° slope within, the patch shape is complex, patch edge curve is smoother, the lower level of human disturbance; Dryland inter-planted with fruit trees are mainly distributed in 2° ~ 6° and 6° ~ 15° slope, have less human interference and effective patch area is fairly small, gradually transition to a fruit tree garden.
(3) Different slope gradients farmland landscape pattern characteristics is different, so , protecting cultivated land resources in different emphasis, which should put the farmland landscape patterns as the key part of sustainable utilization and protection of farmland. 2° ~ 6° and 6° ~ 15° slope gradient are the main distribution of Gongyi city farmland, the most frequent human activities, is the main area of farmland utilization and protection. Conducting land use planning, sustainable use farmland and protection of basic farmland division should be the focus of consideration.
(4) The farmland use is a complex process. The multiple cropping index, the farmland investment, the intensity of human use, *etc*., such as how to influence between the farmland ecological system and ecological system of energy, material and information exchange will be the future research key points and difficulties of sustainable utilization of farmland.

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