

Rural Landscape Planning Based on Ecological Analysis: A Case Study of Shuangdun Village, Huangpi District, Wuhan City

Foreword

At present, rural area in China is in the transition from traditional to modern agricultural landscape, large population pressure, a lot of artificial auxiliary has been imported, which results in the diminishing diversity of village inhabitant and fragmentation of natural landscape, land-use and land-cover changes, village landscape has undergone severe deterioration. Rural industry is booming, material, energy, information flows and transmits between the landscape elements, the rural landscape layout changes and environmental problems stand out. So that, small scale rural ecological study can't meet the needs of the rural sustainable development. The paper aims to rescan present village landscape planning, use eco-landscape theory, to do planning of village landscape layout based on ecological analysis, in order to resolve the ecological problem of village.

1 Main research contents and technical route

1.1 Research method

The paper presents a case study of Shuangdun Village, Huangpi District, Wuhan City and analyzes the current situation of the landscape layout of the research area; introduce and apply the landscape ecology theory and method in the village planning, from landscape structure, function, ecological planning. As the research methods, adopt on-the-spot investigation, planning and empirical combination. In technology processing, according 1:10000 topographic map for reproduction, such maps application process analysis tools such as ArcGIS.

1.2 Technical route

The technical route shows in figure 1.1.

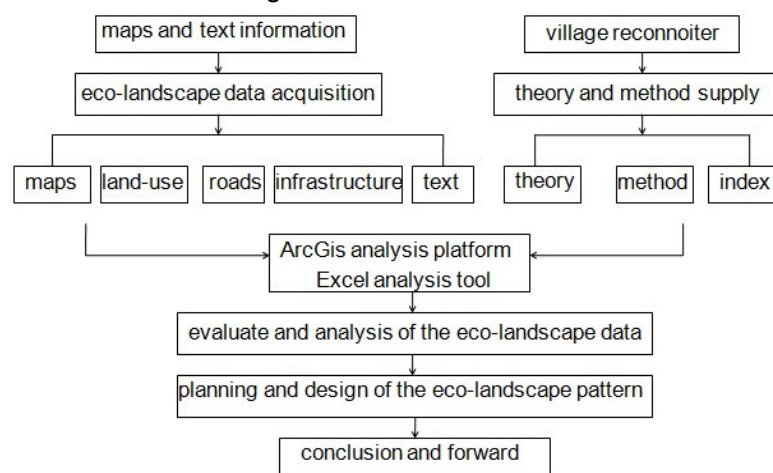


Figure 1.1 Research technical route

2 Background of the research area

2.1 Location and area

Huangpi locates in north of Wuhan city, belong to wuhan suburbs, featuring subtropical monsoon climate, abundant precipitation, sufficient sunlight, quantity of heat and four distinct seasons. Shuangdun Village locates in southwest of Qijiawan Street of Huangpi. Village domain area is 5.10 square kilometers.

2.2 Nature and geography

Shuangdun Village is typically hilly area; there are two rivers, six kilometers long, with 14 larger pools. The village is near lake district, though most natural bay is located in high lands, there is still flood hidden trouble.

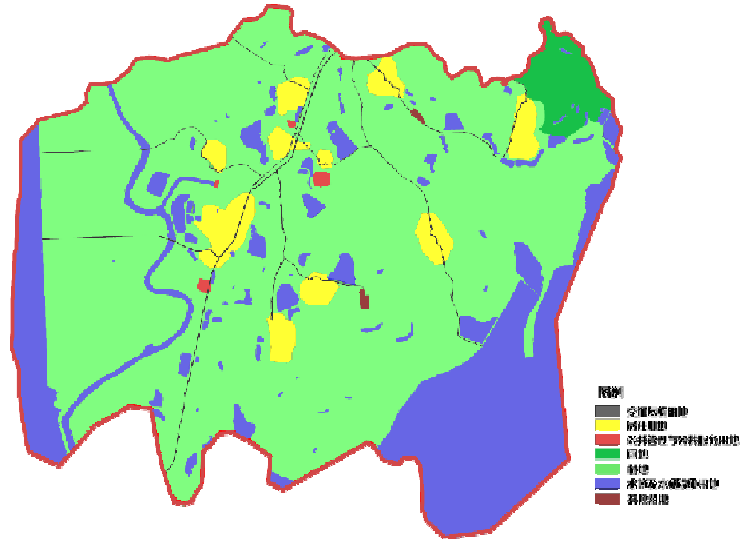


Figure 2.1 Land use status chart

2.3 Social economic

Shuangdun Village domain area is 5.10 square kilometers, cultivated land is 5331 mu, water area is 1283mu, and the population is 2037. The natural conditions conducive to crop production and aquaculture, the village industry is mainly in aquaculture, rice planting and labor economy.

3 The establishment of landscape ecological index system

3.1 Landscape structure

The basic elements of landscape are patch, corridor, and matrix, combined with the present situation of Shuangdun Village, classify the landscape elements as follows:

Table 3.1 Landscape elements classification

Plaque	Corridor	Matrix
Residential、Artificial facilities、Pool 、Trees	Road、Rivers、 High-pressure corridor	Farmland 、 Water area

Among them, artificial facilities are floor, chicken farm, factories and so on, trees are fruit trees and economical forest. As with corridor, except the village road and the bay road, there is a east-west 10 kv high-voltage line and a north-south ditch, which divides the village. Matrix is mainly farmland, as there is large water area connected with outside, having effect on village layout, so single it out.

For the patch, corridor, matrix chooses different respectively evaluation factors, used to measure the one class and the overall landscape structure's the influence of the rural

landscape layout, the landscape elements description indicators and description method is as follows:

Table 3.2 Landscape elements description indicators and method

patch index	quantity	perimeter	area	shape	position	density	stretch index
description methods	quantitative calculation	quantitative calculation	quantitative calculation	quantitative calculation (formula1)	qualitative description	quantitative calculation (formula2)	quantitative calculation (formula3)
corridor index	quantity	perimeter	area	curvature	width	density	continuous degrees
description methods	quantitative calculation	quantitative calculation	quantitative calculation	quantitative calculation	quantitative calculation	quantitative calculation (formula4)	qualitative description
matrix index	porosity			boundary shape index			
description methods	quantitative calculation (formula5)			quantitative calculation (formula6)			

Formula describe :

formula 1: $D_i = P/2 \sqrt{\pi A}$, (P: Plaques perimeter , A: Plaques area);

formula 2: $S_i = n_i/A_i$, (S_i: fragmentation , n_i : Plaques number , A_i : The total area);

formula 3: $G = P_i / \sqrt{A_i}$, (P_i : perimeter , A_i : Area, G : Stretch index);

formula4: $M = L_i/A$, (M : Corridor density , L_i : Total length , A : The total area);

formula4: The matrix landscape structure area / The total area ;

formula6: Matrix perimeter / perimeter

3.2 Landscape function

Landscape function mainly reflects in flow and its mechanism. Landscape function is landscape elements' interaction that is due to the differences between landscape elements caused species, material and energy flow between each element. In normal circumstances, these flows will help maintain landscape ecological stability.

The landscape of the elements of the individual characteristics and the overall arrangement of space comprehensive together, influencing the flow of factors and their mechanism. Therefore, we choose 4 kinds of flow movement as the main mode measure.

Table 3.3 Landscape movement pattern

Plaque +Plaque	Species of animals with (such as migration) primarily, by biological movement as the main mechanism, the wind is very small
Plaque + Matrix	Material flow and species flow primarily, the wind, water, biological movement all have effect
Plaque + Corridor	Species flow primarily, plaque is the important species source of corridor ,wind, water, biological movement have effect
Corridor + Matrix	A narrow corridor and matrix happened mainly formed from the corridor to the role of the matrix, so the linear corridor will usually segregation

	population, limit the matrix matrix gene flow, and wider band corridor and both sides flow between matrix is complex, so ribbon corridor and matrix often form dependent on each other
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3.3 Landscape layout

Landscape layout is under a certain scale by different landscape elements formed disordering combination and inlaying landscape space form, is the comprehensive reflection of landscape structure. Choose the following five indicators of the landscape layout analysis:

(1) Diversity index

Diversity is the complexity of landscape pattern, and characterization of the landscape types of how many percentage and its change. Its computation formula is:

$H = -\sum_{i=1}^m [P_i] \cdot \log_2(P_i)$ (H is diversity index, P_i is landscape pattern i's area percentage, m is the number of landscape pattern).

(2) Landscape evenness

It is used to describe the different types of landscape distribution, usually with diversity index and maximum diversity index. Its computation formula is: $J = (H / H_{max}) \times 100\%$, (J is landscape evenness, H is diversity index, H_{max} is maximum diversity index).

(3) Landscape dominance index

Dominance index is used to represent the landscape diversity to the maximum diversity index's degree or describe major landscape types' dominate degree. Its computation formula is: $D_0 = H_{max} - H$, (D_0 is dominance index, H_{max} is maximum diversity index).

(4) Landscape fragmentation degree

It is used to describe the landscape's broken degree in the natural or man-made interference. Its computation formula is: $FN_1 = (N_p - 1) / N_c$, (FN_1 is the landscape fragmentation degree of the research area, N_p is the number of all the patches, N_c is the average plaques area of all kinds of elements described by square).

(5) Landscape connection degree

landscape connection degree means within the region, the connection degree of all kinds of landscape, mainly used as qualitative description, to measure the integrity of the landscape layout, sure the advantage of landscape's unicom, guiding the landscape layout planning.

4 Landscape ecological analysis and evaluation of the research area

4.1 Landscape structure

4.4.1 Plaque

Table 4.1 Plaques' characteristics parameters

	Type	Residential	Artificial facilities	Pool	Garden	Total
Plaques	Quantity(a)	10.000000	8.000000	99.000000	1.000000	118.000000
	Perimeter	6.636000	1.217000	18.353000	1.818000	

(km)					
Average(km)	0.663600	0.158875	0.185384	1.818000	
Area(km ²)	0.228411	0.012812	0.232685	0.128614	0.602522
Average(km ²)	0.022841	0.001602	0.002350	0.128614	0.005106
Shape index	3.916904	3.033033	10.732921	1.430029	
Position	Qualitative analysis				
Density (a/km ²)	43.780729	624.414600	425.467900	7.775200	196.000000
Stretch index	13.885063	10.751823	38.047215	5.069321	

The number of all the Shuangdun Village's plaques is 118, the most is the pool, the number is 99, accounting for 83.90%, but the area percentage is only 39.62. Among them, whose area is less than 0.5 m² accounting for 85.86% I, quite a large proportion. In general, the more plaques, the higher of landscape and the number of species diversity is, but small patches reflect that landscape fragmentation degree is high, the human activities of interference is not easy to restore.

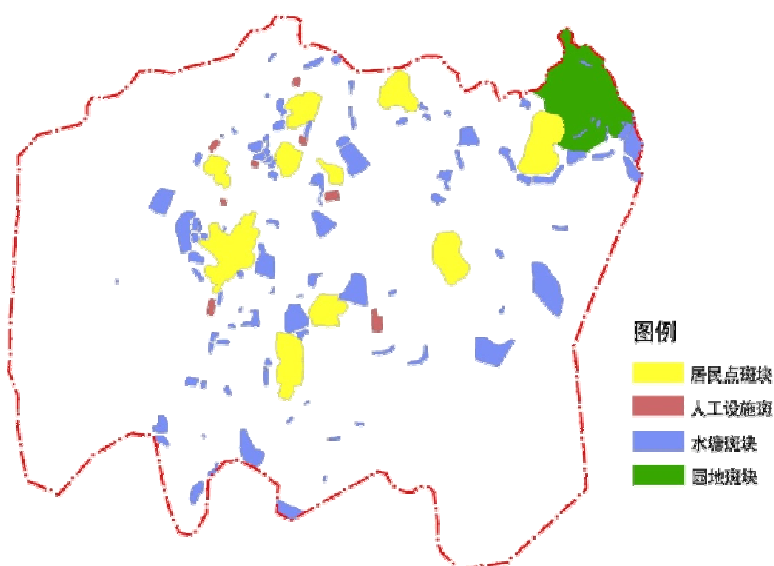


Figure 4.1 Plaque's status chart

Planning to integration, form system, reduce the pool landscape's fragmentation degree. The shape index of patch pool is high, mainly because of small patches, large pool' shape is rules, their biological diversity and edge effect can cause certain offset. In planning, we should try to make these shape-simple plaques complicated. Plaques average density is 196/km², of which pool and artificial facilities is higher, reflect its human interference is of large degree, fragmentation degree is high. The pond's high stretching index reflects its belt pool's higher percentage.

As human interference plaques, the type of residential areas and artificial facilities account for the relatively large proportion. The average residential plaque's area is large, but from the status, the intensive utilization of land is insufficient, encroaching on other land. The shape index is high but very irregular, this is mainly because many country is spontaneous, lack of unified planning, to the aggressive farmland obviously. There are 10 villages scattered distribution, lack of communication between each bay, which should be combined with the village of intensive construction integration. Shuangdun Village has only one garden patch, a simple landscape shape of patch will affect edge effect and habitat condition.

4.4.2 Corridor

Table 4.2 Corridor's characteristics parameters

	Type	Road	Rivers	High-pressure corridor	Total
Corridor	Quantity (bar)	1.000000	1.000000	1.000000	3.000000
	Perimeter (km)	4.432000	5.572000	5.637000	15.641000
	Average(km)	4.432000	5.572000	5.637000	
	Area(km ²)	0.010552	0.074393	0.008447	0.093392
	Average(km ²)	0.010552	0.074393	0.008447	
	Curvature	1.027744	1.587802	1.005898	
	Width (m)	4.760000	26.700000	3.000000	
	Density (km/km ²)	0.434436	0.546182	0.552553	1.533171
	Continuity	Qualitative analysis			

Shuangdun Village has 3 corridors, all are the linear corridor. Among them, there is one river corridor, located in the west village, mainly used for irrigation, and the biological diversity and material, energy exchange by certain constraints, rivers and reservoirs and also without much contact, so have not formed a good water system, but they increase the whole landscape layout of fragmentation.

Road corridor is mainly a village road, because its width is narrow, and combined with the construction of residential areas, farmland etc, thus decorate factors on the landscape is not obvious.

Shuangdun Village has a 10 kv high pressure corridor, corridor curvature close to 1, the impact is very small. According to specification, on each side of 1.5 m, back in this area can not be used in building construction, and reduce the flow through or to stay. In this area more than present situation for farmland, satisfy the standard requirements.

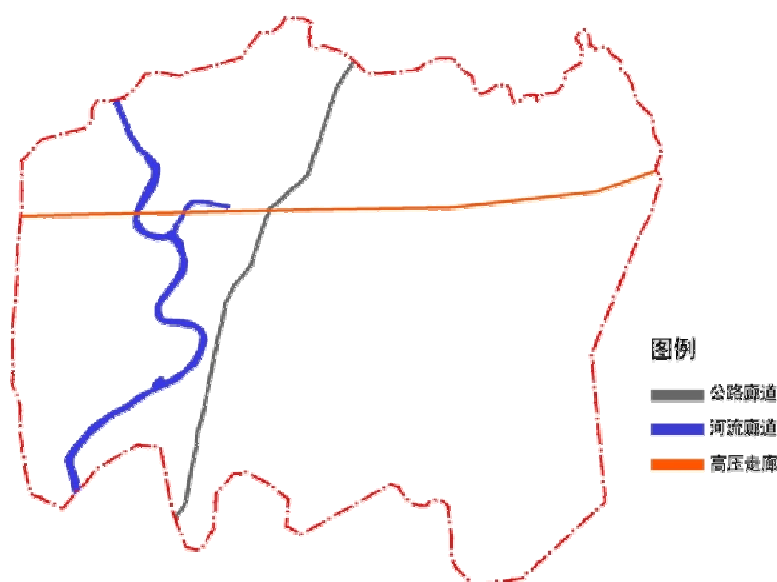


Figure 4.2 Corridor's status chart

4.4.3 Matrix

Table 4.3 Matrix's characteristics parameters

	Type	Farmland	Pool
Matrix	Porosity	0.303227	0.832259
	Boundary shape index	7.775203	2.701097

With a total area of 5.105684 km² Shuangdun village, including farmland area of 3.554146 km², accounting for 69.60% of the total area, it is a farmland as the main body, therefore in the landscape ecological planning of landscape pattern should focus on the protection of farmland this landscape type. As the matrix of the landscape water area of 0.855624 km², accounting for 16.80% of the overall landscape area, in the landscape ecological planning should be paid more attention.

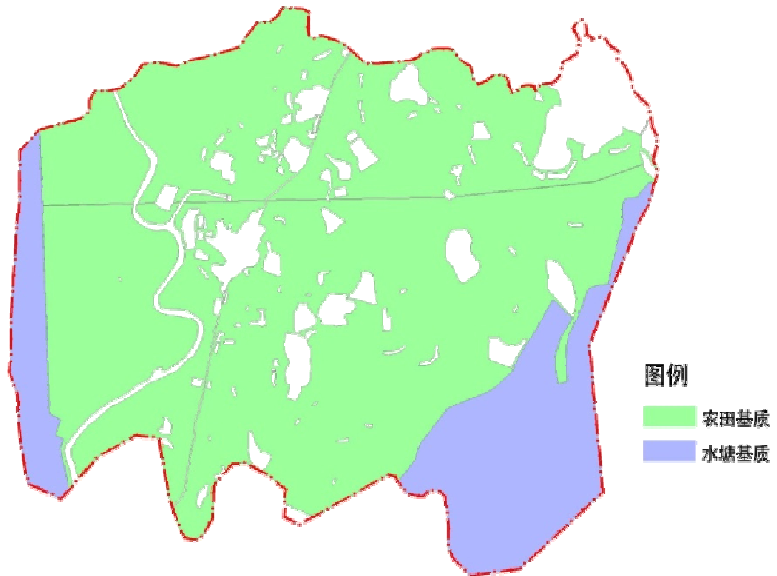


Figure 4.3 Matrix's status chart

Shuangdun village's plaques are of scattered distribution, causing boundary shape index on the high side, although for biodiversity and physical energy exchange, but resulting in the size of the farmland high effective production by certain constraints. In contrast, pool outside the waters with large matrix, so its landscape integrity is stronger, can use this piece of areas of water scene, so as to enhance the overall quality of the rural landscape.

4.2 Landscape function

To analysis landscape structure's function, make the matrix, sure the factor of influence between each other , shows as below:

Table 4.4 Plaque+ plaque function

Plaque + plaque	Residential	Artificial facilities	Pool	Trees
Residential	■	■	■	■
Artificial facilities			■	
Pool			■	■

Table 4.5 Plaque + matrix function

Plaques + Matrix	Residential	Artificial facilities	Pool	Trees

Farmland	■	■	■	■
Water area	■		■	

Table 4.6 Plaque + corridor function

Plaques + Corridor	Residential	Artificial facilities	Pool
Road	■		■
Rivers	■	■	■

Table 4.7 Corridor + matrix function

Corridor + Matrix	Road	Rivers	High-pressure corridor
Farmland	■	■	■
Water area		■	

(1) Plaque+ plaque

The flow movement between residential plaque and other plaques is obvious by leaps, performance as the material and energy exchange brought by the flow of people, but the pool flow movement because of discharge sewage. Among them, the influence to pool's degree is the most obvious, mainly for damage. Instead, water flow movement's relationship is weak, which should be enhanced to create a more stable and varied landscape system.

(2) Plaque+ matrix

The village's plaques and matrix have certain movement, such as farming and the supply of energy, but agricultural chemical fertilizers bring to pool environment quality. From the view of ecological, farmland and the pond flow movement is most important, planning should be considered.

(3) Plaque+ corridor

Road corridor and residential areas, there are certain influence, but does not play a significant role, mainly for flow movement with operation corridor. Rivers and plaques' flow movement is more apparent, is mainly residential areas and energy, material exchange, planning should be enhanced this movement. High pressure is not through plaque, the influence is small. Among them, the most favorable influence is rivers, highways.

(4) Corridor + matrix

Highway in farmland matrix produced segmentation effect, causing convection of the movement been cut off. The river corridor positive effect is significant, long and curvature high can promote such material and energy of the exchange, and can enrich matrix landscape. At the same time, Shuangdun village has large area of the reservoirs matrix, and planning should be considered in the river corridor, strengthen the connection of the landscape.

4.3 Landscape layout

Table 4.9 The landscape pattern parameters

Type	index
Diversity index	1.477322
Landscape connection degrees	Qualitative analysis

Landscape evenness	0.424352
Landscape fragmentation	0.002657
Landscape dominance index	1.719836
Landscape concentration	Qualitative analysis

Shuangdun 's landscape diversity index is low, the number of landscape type is small, species with low levels, planning needs to enrich the landscape and the landscape types of diversity. Diversity index is 1.477322, the biggest diversity index is 3.169925, the advantage degree clear, it shows that all kinds of landscape type proportion of large disparities. From the homogeneous degree, the homogeneous degree is 0.424352, also shows that all kinds of landscape types area size has large difference, and don't even, has some landscape types (such as farmland, pool) dominant, just as the advantage degree 1.719836. Therefore, in the landscape layout planning can take appropriate human interference to make adjustment, to improve the present small area of the landscape scattered and to improve types of diversity index.

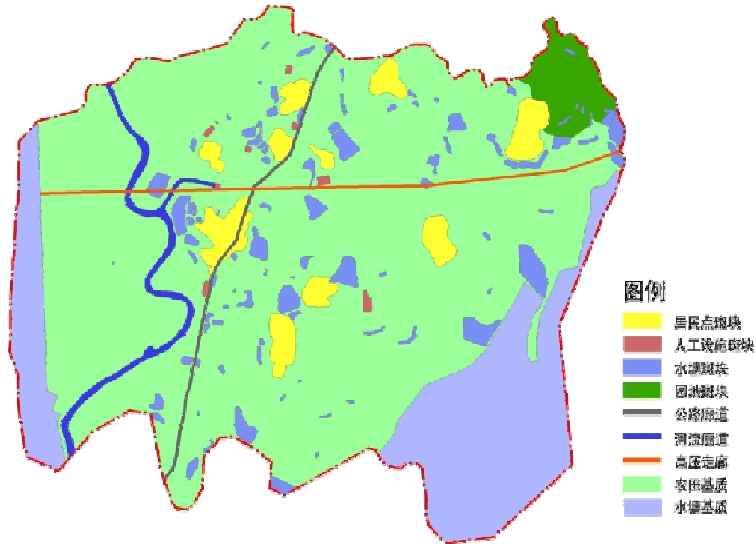


Figure 4.4 Layout's status chart

The village's landscape fragmentation is small, the interference strength to landscape is low, the country keep the original landscape layout. From the whole pattern, landscape types for farmland, rivers, and ponds have the advantage. The development goal of farmland is mainly large-scale production and the earth landscape; rivers and reservoirs connected to establish the system of the whole building, space pattern, on the other hand, as the ecological landscape, it should adjust and improve the quality of the landscape. Residential areas have the most effect on landscape layout, they can change by demolition, integration and intensive construction of landscape to reduce its interference, and formed a "nature and humanity" harmonious ecological realm.

5 Landscape layout planning and design of the research area

5.1 Thought and measures of planning and design

5.1.1 Thought

First of all, to consider protection or construction layout which is a few as water conservation and local biological kind of maintain large-scale natural plate -- existing vegetation protection and a certain distance from human area, namely the "core". Second,

there are enough width corridor to protect the water system and meet species space motion. Finally, based on the edge effect, should be appropriately increase the diversity of the landscape elements, establish a relatively complex species relationship, enhance the stability of the ecological system.

Based on the system of landscape analysis, in the spirit of landscape ecological integrity and spatial heterogeneity of the two basic thought, to realize the save of rural ecological resources and environmental protection as the basic goal, which is species diversity, landscape diversity and resource utilization of sustainability, to do the landscape layout overall planning and design.

5.1.2 Specific measures

- (1) Construct the artificial ecosystem, high efficiency land intensive management, protect the concentration of farmland matrix;
- (2) Control building plaques construction which is reckless expansion, to construct the pleasant living environment;
- (3) Reconstruct the vegetation plaque, adjust measures to local conditions to increase green corridor and distract the natural plaques, restore landscape ecological functions;
- (4) In engineering construction area, reshape natural systems to harmonize the landscape;
- (5) To make full use of existing resources and local materials, using the low cost to build high quality rural landscape;
- (6) The ecological protection must be combined with economic development, through the human production activities to do ecological construction, such as soil fertilizer project, shelter forest construction, agriculture structure adjustment, etc.

5.2 The overall landscape layout of planning and design

- (1)Center radiation: farmland matrix as the core to spread outside.
- (2)Two belts around: natural corridor is the composition of restore wetland and river system.
- (3)Contact relationship: integration of natural plaques scattered, relying on farmland matrix and wetland river corridor , construct a continuous landscape ecological layout.

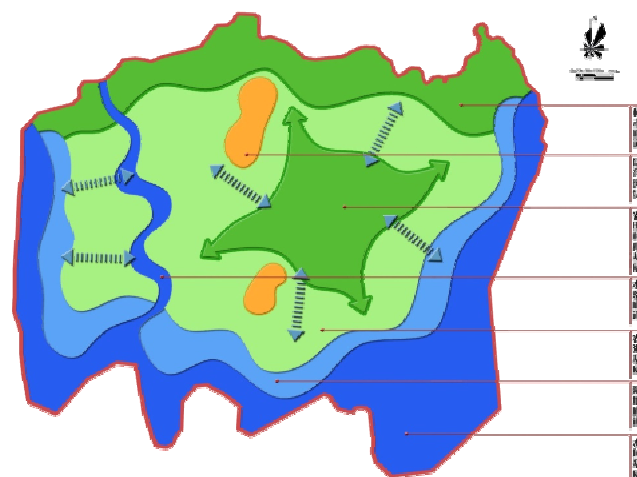


Figure 5.1 Layout's planning chart

Conclusion

The landscape ecology theory and methods are proposed to village landscape planning and design, which has the theoretical feasibility. Rural landscape multiple-level comprehensive planning and design should adjust measures to local conditions, and relate theory to practice. Rural landscape ecological layout planning is an important part of regional village planning, they are the same in space, the basic purpose, planning drawing, but the former is guiding ideology, the planning concept, the starting point, the solution of the problem is much better than traditional rural planning, and it can effective global and local levels, determine the further spread of landscape structure units and their combination.

Village landscape planning and design use relevant principles in landscape ecology, based on the optimization of the original landscape elements combined, adjust and tectonic new landscape layout. Drawing upon the PCM pattern (patch, corridor, matrix), mode the significance of not only provided a planning process, it helps to realize "planning combined with the natural" thought, meet the requirement for sustainable development of the village, to keep ecological balance and people, to coordinate to the ecological planning and design advocate goal.

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