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SYNTHETIC EVALUATION OF ECO-ENVIRONMENT BY ENTROPY WEIGHT METHOD

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Abstract: The application of entropy in environmental studies aims to determine the weights of environmental factors for evaluation of eco-environment so as to carry out synthesized evaluation. We can take entropy as index of information for eco-evaluation. Every characters of the subject-object of ecosystem can be measured with entropy to get their information. The interaction between factors of function of entire ecosystem, production and stability can be indicated by information entropy of relation between factors, because the entire ecosystem can be explained with its composing. In this article, as the main contribution, an evaluation of a region's eco-environment is performed by means of entropy weight method and the whole used technology is presented.

Keywords: Eco-environment, Synthetic Evaluation, Entropy Weight Method

СИНТЕЗИРАНА ОЦЕНКА НА ОКОЛНАТА СРЕДА ЧРЕЗ МЕТОДА ЕНТРОПИЯ НА ТЕЖЕСТТА

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Резюме: Прилагането на ентропията в изследванията на околната среда има за цел определяне на тежестта на отделните фактори на тази среда при извършването на системна оценка на екологичното състояние. В този смисъл ентропията може да бъде използвана като индекс на информацията за екологичната оценка. Всички елементи на екосистемата могат да се измерват с ентропия за получаваната информация. Взаимодействието между факторите за функциониране и стабилност на цялата екосистема може да бъде показано чрез ентропия на информацията за отношението между тези фактори като съставни елементи на системата. В настоящата статия като основен принос се извършва оценка на екологичното състояние на околната среда на избран район чрез метода ентропия на тежестта и се представя цялата използвана технология.

Ключови думи: околна среда, системна оценка, метод ентропия на тежестта

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INTRODUCTION

According to the entropy, the information and quality we got from the evaluated objects in synthetic evaluation of eco-environment, are the deciding factors in evaluating precision and reliability. The entropy as the appraisal information's measure unit is a very useful criterion. Entropy is used popular in the information's measurement into the domain of manage and decision-making (He et al., 2009). The researchers applied entropy to determine the weights of environmental factors for evaluation of eco-environment so as to carry out synthesized evaluation (Guo et al., 2009; Fang et al., 1998; Fang, Wang, 2001; Fang et al., 2001). We can take entropy as index of information for eco-evaluation. Every characters of the subject-object of ecosystem can be measured with entropy to get their information.

DATA AND METHODOLOGY

The interaction between factors of function of entire ecosystem, production and stability can be indicated by information entropy of factor's - relation between factors, because the entire ecosystem can be explained with its composing. For their contribution to the system in this study, the region's eco-environment is evaluated based on calculation of entropy weight and the whole technology is presented (Figure 1). Entropy weight method is based on amount of information to determine the index's weight, which is one of objective fixed weight methods.

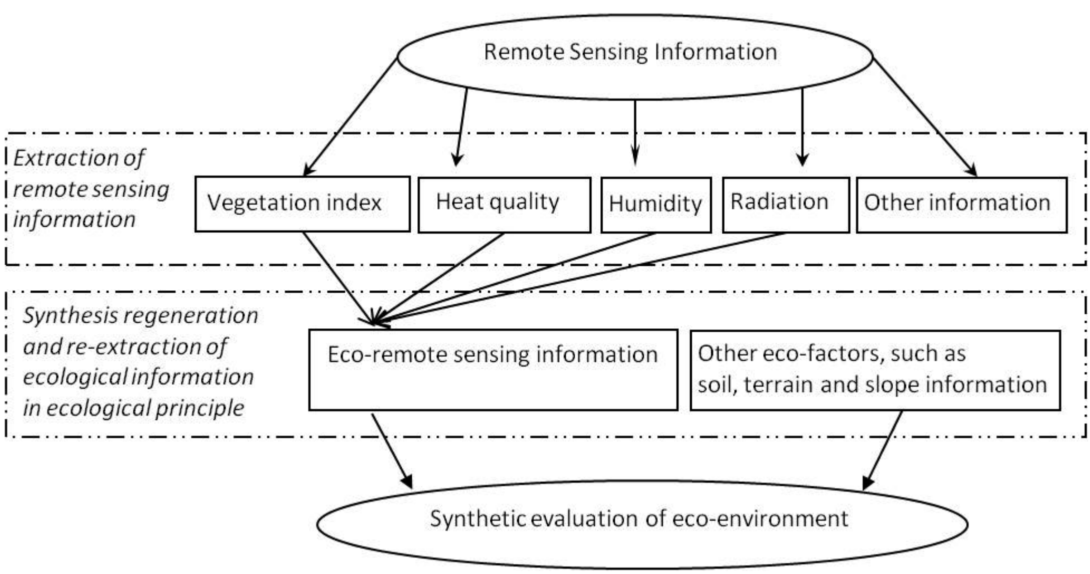

Figure 1. Procedure of eco-environment's evaluation in remote sensing

BASIC DATA

In this study, Fuzhou (including six areas and eight counties) was selected as the study area for its typical geographic climatic location in Fujian province, which will have typical significance in vegetation- eco-environment evaluation. Thus the evaluated method can be used as reference to the entire province or close local area.

GEOGRAPHICAL LOCATION PROFILE OF FUZHOU

Fuzhou city, which covers 11968 square kilometers, is located in the middle of the Fujian province, with geographical coordinates: 25°15′~ 26°39′N, 118°08′~ 120°31′E. The Fuzhou city's neighboring territories are as follows: to the East – the East Sea, faces one another with Taiwan Province, to the west – next to Sanming and Nanping, to the north – meets Ningde, to the south – connects with Putian. The city of Fuzhou governs six areas continually (Gulou, Taijiang, Cangshan,Mawei,Jinan and Langqi) and eight county cities (Minhou, Changle, Fuqing,Pingtan, Lianjiang, Luoyuan, minqing and Yongtai) in the administration.

ENVIRONMENTAL PROFILE

The city of Fuzhou, having a topography descending from west to east, is surrounded by the lu-Daiyun mountain to the west and by the East sea to the east. The Min river going across from northwest to southeast, runs in the Fuzhou basin and forms the Fuzhou plain – one of the biggest plains in Fujian province. Da-zhang and Mei's rivulet form small valley plain when they flow around basin.

The Fuzhou region falls into subtropics and the South Asian tropics and has a subtropical marine climate, nice and warm moist, suitable for the forest and the crops growth. Crops can be sown three times a year in the plain, but meteorological disasters such as drought -flood and typhoon are quite still serious. Mountain climate's vertical variation is also quite obvious, thus also causes the soil and vegetation's vertical distribution difference.

VEGETATION PROFILE

According to the "Fujian vegetation," published in 1990, Fuzhou vegetation crosses the subtropical south Asia's tropical rain-forest belt and the subtropical middle Asia's evergreen broad-leaved forest zone in the principle of vegetation-class. It belongs to middle –Min, east–Min, peak lu–Daiyun mountain evergreen chu–style forest from the west of Fuzhou hills to peak lu-Daiyun Mountain, which is evergreen broad-leaved forest zone. Fuzhou Eastern hilly terrace to the East sea belongs to south Asia's tropical rainforest. The northern and the southern territories are demarcated by Fuqing guankou – Fuqing qiyan mountain – Pingtan bay, the northern area belongs to Minjiang – peak lu moist-warn south Asian rainforest belt, the southern zone covers a small area of Fuzhou city, which belongs to the south Min – east Daiyun moutain wet-warm south Asian rainforest belt. Most of the vegetation of Fuzhou belongs to middle–Min, east–Min, peak lu–Daiyun mountain evergreen chu–style forest and Minjiang–peak lu moist-warn south Asian rainforest belt.

All results and information were obtained from three-time series of Landsat TM satellite images of Fujian remote sensing and geology center. The dates of images acquiring are as follows: 04.09.1989, 05.04.2000, and 03.07.2002. Specific technologies include pre-processing of remote sensing images (Figure 2) and calculation of ecological environment background value (Table 1).

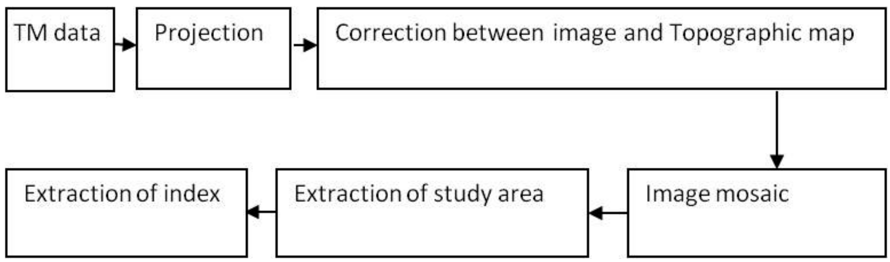

Figure 2. Pre-processing of remote sensing data (satellite images)

Table 1

Vegetation indices of environmental evaluation

One class index	**Two class index**	**Method**	**Source**
Vegetation index	NDVI	(TM4-TM3) / (TM4+TM3)	ETM Data
	RVI	TM4/TM3	
	ARVI	(TM4-TM2) / (TM4+TM2)	
	TMG	Green index from Tasseled Cap	
Humidity index	NDMI	(TM2-TM5) / (TM2+TM5)	
	TMW	Humidity index from Tasseled cap	
	MI	100×NDVI/ T_s	
Soil brightness index	NDSI	(TM3-TM2) / (TM3+TM2)	
	GRABS	TMG-0.09178TMB+5.58959	
	TMB	Soil brightness index from Tasseled cap	
Radiate information	PC1	the first component from TM's PCA	
	PC2	the second component from TM's PCA	
	PC3	The third component from TM's PCA	
Heat index	T_s	$Ts = K_2 / ln (1 + K_1 / (L_{(\lambda)})$	
Topography data	DEM	TINLATICE analysis	1; 100000 Contour line
	SLOPE	Slope analysis	

RESULTS AND DISCUSSION

THE ENTROPY EVALUATION OF ECO-ENVIRONMENT

In environmental evaluation of vegetation, we choose *m* evaluation indices, *n* evaluation units (the number of remote sensing grid image in the case study). As the evaluation indicators are all quantitative data therefore, many indicators can be constructed into evaluation matrix:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

normalize R and gets follows

$$R' = (r_{ij}')_{m\times n}$$

$$r_{ij}' = \frac{r_{ij} - \min(r_{ij})}{\max(r_{ij}) - \min(r_{ij})}$$

If choose *m* evaluation indices, *n* evaluation units, then the entropy of the number *i* can be defined as :

$$H_i = -k\sum_{j=1}^{n} f_{ij} \times \ln f_{ij}$$

$$i = 1,2,\cdots,m$$

$$f_{ij} = \frac{r_{ij}'}{\sum_{j=1}^{n} r_{ij}'}$$

$$k = \frac{1}{\ln n}$$

$$if \quad f_{ij} = 0, then \ f_{ij} \ln f_{ij} = 0$$

Under the processing of *“m”* and *“n”*, the entropy of the number *“i”* can be defined as:

$$\omega_{\mathbf{i}} = \frac{1 - H_i}{m - \sum_{i=1}^{m} H_i}$$

$$0 \le \omega_i \le 1$$

$$\sum_{i=1}^{m} \omega_i = 1$$

$$\omega_i : the \ entropy \ of \ the \ number \ i$$

From the definition of entropy and entropy weight, we can get the characters of entropy as follows:

(1) The entropy weight gets the value "0", while Entropy gets the biggest value "1" in the condition that the objects of evaluation have the same "j", it indicates that this indicator is useless in showing information, so it can be canceled.

(2) The entropy weight gets a big value, while entropy gets a small value in the condition that the objects of evaluation have a big difference in index "j", it means this indicator shows useful information and also indicates that each evaluated unit has sensitive indication functions, so we should pay much more attention to it.

(3) The bigger the entropy, the less the entropy weight means the less important the index.

(4) The meaning of the entropy with determinate index is to tell us the importance of each index in the system. Considering from the information, it stands for the quantity of useful information.

(5) The value of the entropy weight relates directly to the evaluated objects. Under the determinate evaluated objects, making adjustment and fluctuation according to the entropy weight, in order to make more precise and reliable evaluation.

EVALUATION TECHNOLOGY ROUTE OF ECO-ENVIRONMENT BY ENTROPY WEIGHT METHOD

According to the entropy and the entropy weight, taking grid remote sensing index and terrain slope data as data source, in this study, the entropy and the entropy weight of each index in 30 ×30 m^2 unit is calculated using evaluation index set including the most useful factors which can reflect the eco-environment in physical and statistical meaning. After liner weight calculating by entropy weight, a quantitative synthetic map reflecting the eco-environment is developed. Then, the class for the synthetic evaluation map is determined according to the ecological relationship, which is called qualitative "Evaluation of Eco-environment" of Fuzhou city. Specific steps of technical route of entropy evaluation are as follows:

(1) *Tentative choice of evaluation index.* Tentative choice of evaluation index and the previous work are presented in Figure 3.

(2) *The Entropy and the entropy weight's calculation of evaluation index.* Firstly, matrix of evaluation objects and index is built. In this study, 7065×5034 grid units as study area and tentative chosen RVI, Ts, MI, GRABS, PC1, PC2, PC3, DEM, SLOPE nine indices are investigated.

(3) *Applications of the evaluation index entropy weights.* The entropy value of each index is sorted, and the threshold of entropy weight value is set to choose the evaluation index. Considering the entropy weight as weights, the entropy evaluation equation is constructed that reflects vegetation eco-environmental quality. Then, this evaluation equation is used to calculate the vegetation eco-environmental quality value of the study area.

(4) *Classification of the eco-environment quality map.* According to the ROI of the field investigated, the analysis on vegetation, ecological factors characteristics and ecological relationship, the reasonable classification interval of the eco-environmental quality value is determined and quality level graph partition is conducted. In this study, the hierarchy classification based on eco-environment quality is associat-

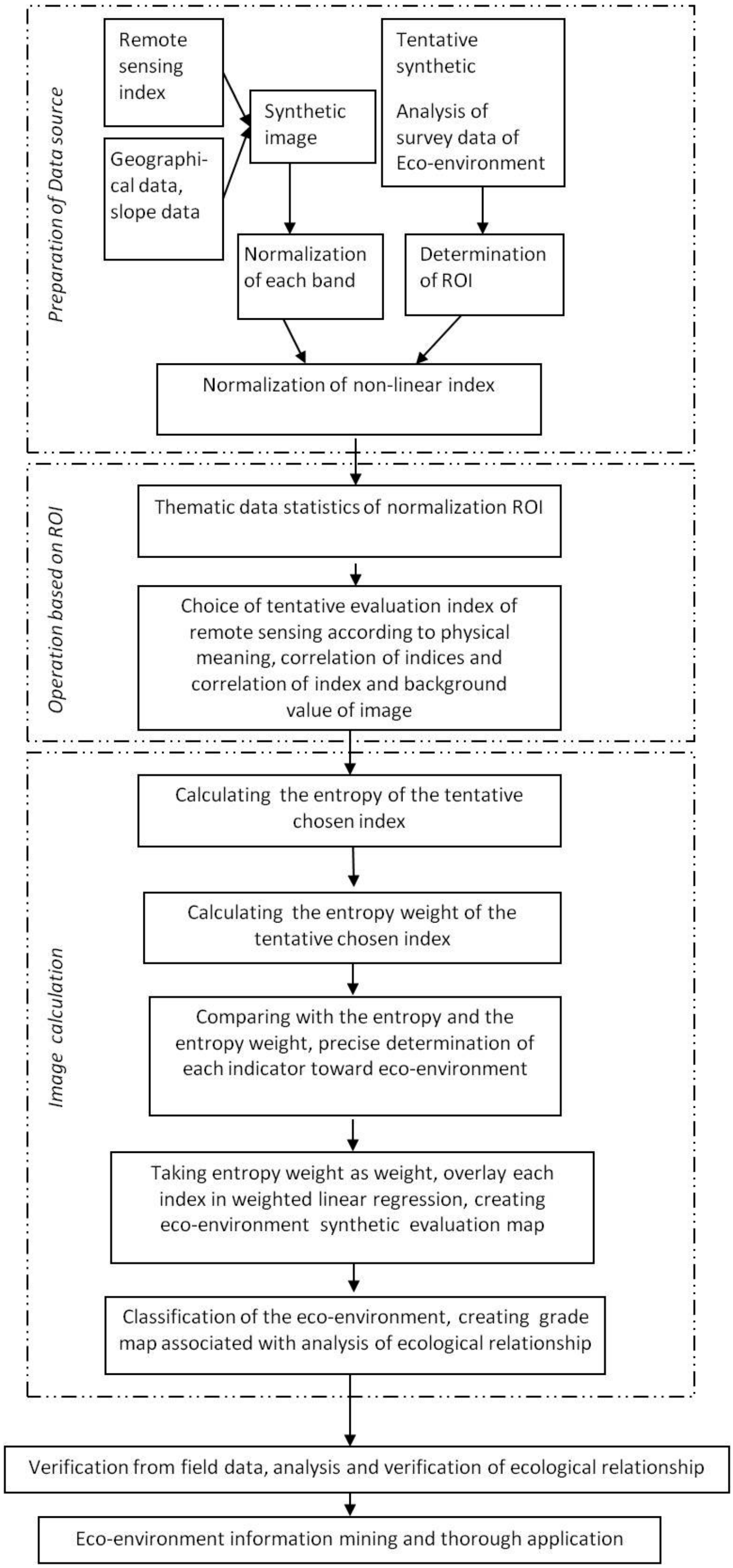

Figure 3. Evaluation technology route of eco-environment by Entropy weight method

ed with the comprehensive analysis results of the vegetation eco-environment types (Figure 3).

(5) *Field validation.* According to the eco-environment quality rank figure, the category and regions that have questions are checked, and field validation is conducted when necessary.

(6) The explanation of eco-environment quality rank figure and the digging utilization of ecological information can be used as reference in such aspects as eco-environment construction and environmental management decision-making, and government development planning.

ENTROPY WEIGHT EVALUATION RESULTS

According to the above technical route using three-year time series remote sensing (RS) data from 1989, 2000 and 2002, as well as terrain gradient data as data sources, nine indicators RVI, Ts, MI, GRABS, PC1, PC2, PC3, height, and slope are calculated, then the entropy and entropy weight of index are determined (Table 2).

Table 2 shows the following results:

1. The indicative function of the eco-environment of these nine indicators are not in significant different. Entropy weight fluctuate between 0.0929 ~ 0.1291;in 1989 the entropy weight is the maximum, shows the large variability of humidity index in the study area, and for eco-environmental quality in space changes identification it plays an important role; Secondly for height, slope, RVI three index, Vegetation index is an important index that reflect ecological subject itself attribute, elevation and gradient as reflect surface rolling indexes, they play a leading role of the ecological environment quality change. Other indicators such as soil brightness index and bright temperature index for indicative function of eco-environmental quality are relatively weak; In 2000 image MI (humidity index) entropy value is the largest, the smallest is still bright temperature index Ts;2002 image Ts entropy value is the largest, the smallest for RVI, PC1, PC3.
2. Different TM imaging of different years, the same index to the ecological environment quality and spatial variation of indicative function is different. Such as Ts in April 1989, May 2000 its entropy weight is the minimum one, but in March 2002 its entropy weight is the maximum one.
3. According to the analysis of TM images index of three time, find that entropy weights of MI index is relatively larger, PC3 and GRABS the entropy weights are relatively minor. Shows that surface coverage related surface humidity index for spatial change of vegetation eco-environmental quality has relative sensitivity, but soil bright temperature index and the third component of principal component analysis for spatial change of vegetation eco-environmental quality has relative slow.
4. Terrain gradient index for spatial distribution of vegetation eco-environmental quality has certain leading role. From three years index entropy value, entropy weight of terrain gradient index is bigger.
5. Inherent laws that influence vegetation eco-environmental quality: Terrain gradient is the dominant factor, On the basis the vegetation index and humidity index have sensitive indicative function, indicative function of bright temperature index is not stable, other RS index indication are role in general.

Order of entropy weight:
1989: Ts<GRABS<PC3<PC2<PC1<DEM<SLOPE<RVI<MI
2000: Ts<PC3<GRABS<RVI<DEM<SLOPE<PC1<PC2<MI
2002: PC1<PC3, RVI<GRABS<DEM<SLOPE<PC2<MI<Ts

Table 2

Entropy weight of evaluation index of Fuzhou eco-environment

Year	Index	Value of the entropy	Value of the entropy weight
1989	RVI	0.2787	0.1144
	Ts	0.4140	0.0929
	MI	0.2611	0.1172
	GRABS	0.3160	0.1085
	PC1	0.2818	0.1139
	PC2	0.2873	0.1130
	PC3	0.2966	0.1115
	dem	0.2794	0.1143
	slope	0.2791	0.1143
2000	RVI	0.2848	0.1133
	Ts	0.4103	0.0934
	MI	0.2731	0.1152
	GRABS	0.2866	0.1130
	PC1	0.2772	0.1145
	PC2	0.2759	0.1147
	PC3	0.3210	0.1076
	dem	0.2794	0.1141
	slope	0.2791	0.1142
2002	RVI	0.2863	0.1078
	Ts	0.1453	0.1291
	MI	0.2605	0.1117
	GRABS	0.2824	0.1084
	PC1	0.2869	0.1077
	PC2	0.2726	0.1099
	PC3	0.2865	0.1078
	dem	0.2794	0.1088
	slope	0.2791	0.1089

Building synthetic evaluation liner equation based on weight of index as follows:

1989: value=0.0929×Ts+0.1085×GRABS+0.1115×PC3+0.1130×PC2+
0.1139×PC1+0.1143×DEM+0.1143×SLOPE+0.1144×RVI+0.1172×MI
2000: value=0.0934×Ts+0.1130×GRABS+0.1076×PC3+0.1147×PC2+
0.1145×PC1+0.1141×DEM+0.1142×SLOPE+0.1133×RVI+0.1152×MI
2002: value=0.1291×Ts+0.1084×GRABS+0.1078×PC3+0.1099×PC2+
0.1077×PC1+0.1088×DEM+0.1089×SLOPE+0.1078×RVI+0.1117×MI

On the integrated image according to the discretion of eco-environment quality value, combines with ecology main body of the previous chapters - vegetation type distribution and area, analytical results of ecological relations, and reference ground investigation interest area, repeatedly acknowledgment and confirm the rank threshold of ecological environment quality, finally, grading of the ecological environment. Figures 4-9 (appendix) present assessment results of entropy weight of vegetation eco-environmental quality.

Figures 4, 5, and 6 more clearly show the spatial distribution of vegetation eco-environment of the study area, and the basic rule is similar to the RS background values rule of Fuzhou vegetation eco-environment. What is different the entropy weight evaluation method is more emphasize the leading role of terrain gradient in ecological index, and vegetation eco-environmental quality along with different altitude and gradient combination has certain gradient distribution rule.

Figures 4 and 5 present respectively the vegetation eco-environment quality transverse sections of the northern and southern area studied from the west to the east, and gather longitudinal vertical section 6, 7, 8, and 9 along the Minjiang river from east to west. Each sampling route of cross-sectional and longitudinal section is shown in table 3.

Table 3

Coordinates of the transverse and vertical section's sampling line

Position	Direction	Point	Point
North section (luoyuan county)	From west to east	26°6′41.10″N, 118°6′56.91″E	26°6′21.59″N, 119°8′45.10″E
South section (teng-shizhu Mountain)	From west to east	25°8′42.40″N, 118°1′17.73″E	25°8′24.30″N, 119°2′50.36″E
Langqi-changle (the East of Minjiang entrance)	From north to south	25°9′20.56″N, 119°5′46.31″E	25°4′27.44″N, 119°5′39.88″E
Fuzhou city of Minjiang-Fuzhou section(cross Minjiang river)	From north to south	26°0′27.31″N, 119°7′47.21″E	25°3′58.08″N, 119°7′29.13″E
Sugar cane town in Fuzhou West Suburbs (cross Minjiang river)	From north to south	26°2′55.03″N, 119°0′5.82″E	26°0′22.09″N, 119°0′3.03″E
Minjiang-Minqing section (cross Minjiang river)	From north to south	26°8′39.61″N, 118°7′6.14″E	26°0′13.36″N, 118°6′53.70″E

(1) The rule of the trend surface of the eco-environment quality distribution: it decreases gradient from west to east.

From the vegetable eco-environment evaluation distribution and the horizontal and vertical profile graph, we can see that the tendency of the eco-environment quality is well at the north-west and poor at the south-east in the study area. Figure 4 shows the northern mountain vegetable eco-environmental quality is reduces from west to east gradually, and its corresponding ecological feature are low mountain shrubs, coniferous–valley bamboo–hilly shrub-grassland–river shoal plain economic forest or rice. Figure 5 is the typical cross section in the southern of the study area. On the southern mountains distributes artificial vegetation – low mountains flora, medial mountains evergreen broad-leaved forest zone (Tengshan nature reserve) – low mountain coniferous forest, shrubbery area – river valley bamboo area form west to east. Extending to the east is the low mound terraced artificial vegetation – alluvial-marine-built plain, and the vegetable eco-environmental quality presents level 6, 3, 1, 3, 4, and 5.

Figures 6 – 9 present four profile graphs from the west to the east of the research area. The profiles were collected from the typical coast eco-environment classes in Minjiang estuary, the typical artificial building eco-environment classes in Fuzhou city, the typical eco-environment classes subjected by the cross effect of the natural and artificial in the suburbs of Minjiang Ganzhe, and the typical eco-environment classes subjected mainly by natural effect and lesser by artificial effect in Minjiang, Fuqing.

(2) The rule of the gradient liner eco-environment quality distribution is the eco-environment quality increases from the centre of river to the river bank. Figures 7 – 9 obviously shows the trendy of the increase of the eco-environment quality, while its extent has a relation with the slope and terrain. The eco-environment quality distribution of the other small rivers and the branch of Minjiang are similar with the condition of Minjiang.

(3) The rule of the weak concentric circles of the eco-environment quality distribution increases from the centre to the outskirts. It means that the eco-environment quality increase from the urban residential area to the outward. Figure 7 shows the rule that the vegetable eco-environment quality is higher in the suburbs of Fuzhou, and lower in the centre of it. The other residential area has the same concentric circles rules.

(4) The rule of the eco-environment quality distribution affected by the terrain has the diversity and complexity, because the terrain has a high fragmentation. Terrain is the eco-environment majority factor, which plays a leading role control the space distribution of other ecological factors. Accordingly the eco-environment quality estimation was affected by the dominant rule.

(5) The relativity of the eco-environment quality is the spatial-temporal relativity. Figures 4 – 9 shows the eco-environment quality is the relativity value of the research area, which changed by its remote image of different times. Therefore, the pixel value of the eco-environment quality has a practical significance only compared with the pixels around it.

(6) The rule of the variation and distribution of the eco-environment quality is similar when it changing with times. The eco-environment quality at 1989-2000 (Table 4) show that the rules of the eco-environment quality variation also have the

Table 4

Correlation coefficient of three-times series remote sensing images' eco-environment quality in the last ten years

Section position	2002–2000	2002–1989	2000–1989
North section (Luoyuan county)	0.8899	0.8373	0.8724
South section (Teng-shizhu mountain)	0.9337	0.9268	0.9347
Langqi-changle (eastern of Minjiang entrance)	0.7108	0.7448	0.8437
Fuzhou city of Minjiang-Fuzhou section (cross Minjiang river)	0.8131	0.7998	0.8523
Sugar cane town in Fuzhou West Suburbs (cross Minjiang river)	0.8744	0.9224	0.9192
Minjiang-Minqing section (cross Minjiang river)	0.8978	0.9073	0.9345

tendency gradient, linear gradient, concentric changes and terrain leading four laws. The changes are greater on the east, smaller on the west, greater on the river bank, smaller on the hill, and greater from the centre of urban to the suburbs, smaller on the area where far from the city, greater on the lower plain, smaller on the steep terrain. Above all, the strength changes are affected by human activities and with little human activities the disturbance are relatively weak.

The eco-environment quality has a correlation between different time certain. Based on the correlation coefficient of different time's eco-environment quality, the strength of the eco-environmental variation degree (Table 4) can be obtained indirectly. The variation is weak when the correlation coefficient is big, while strong when the correlation coefficient is small.

(7) The edge effect phenomenon of ecological environment quality change. Edge effect is that core area influences perimeter zone constantly through its boundary diffusion. The edge of superior core area becomes optimal gradually, while the edge quality of inferior core area is continuously disadvantaged or its area expands along certain axis. The ecological environment area of high quality value in 1989 is still in the highest grade in 2000 and 2002; while the area with low quality value in 1989 its diffusion speed is very fast and drives the quality of its surrounding to be inferior.

(8) The ecological environment variation trend enhanced from west to east. According to the table 4, the ecological environment quality of Minjiang River becomes bad from west to east. The correlation coefficient of ecological environmental quality is big during ten years value (0.9 or so), and the profile of Langqi-Changle, the correlation coefficient of its quality declines obviously (0.7108).

(9) Profile line sampling can be considered as a relatively reliable inspection technology at ecological environmental quality evaluation in different periods. In ENVI, it can overlay result multilayer to sample in profile line and calculate its correlation coefficient or covariance coefficient at all levels. If the correlation coefficient is in a certain threshold, the evaluated result is relatively reliable, or the quality is in poor state.

COMPARING THE EVALUATED METHODS BETWEEN ENTROPY AND REMOTE SENSING BACKGROUND VALUE

Comparing the evaluated methods between entropy and remote sensing background value we can analysis issue from the evaluating technological route and results.

At the aspect of evaluating technological route, the step before the primal choose of evaluating is choosing the ROI and acquiring remote sensing indices according to the investigate results of ecological environment, then the indices could be gained through the correlation between remote sensing indices and ecological environment background value. The differences between them are the integrated courses and methods of information evaluating. Complying with the information for indices themselves ,entropy value and weight are calculated by the entropy evaluating method which is on the premise of the evaluating object (the amount of evaluating cell) and the doubtless evaluating indices. The entropy weight reflects sensitivity that belongs to the differences of the indices information for identifying evaluating objects. The entropy value could distinguish the indication order of evaluating indices to evaluating objects, meantime it could be used to establish the synthetic evaluated equation; Applying regression analysis method for ROIs in the remote sensing background value process of evaluating indices to obtain regression evaluating model, and then this model can be used for all the area calculation. So the entropy weigh evaluating method is inclined to the differences and sensitivities of information for indices themselves. However background value evaluating method applies the grey model of typical samples for all the area.

At the aspect of evaluating results, firstly overlay the results of two evaluating methods, secondly choose ROIs, and lastly compare the grades between the results of two evaluating methods. The two methods will gain the same effect if the two results are unanimous, Choosing the suitable method is on basic of different characteristics. At the same study area, comparative analysis among several periods is indispensable, because there is relativity on the Spatial-temporal, and then all kinds of typical regions of ecological environment which are changing slightly are considered as controlled areas. The satisfied results will gain none but dividing ecological environment into different grades.

DISCUSSION ABOUT THE APPLICATIONS OF SYNTHETIC EVALUATING RESULTS OF ECO-ENVIRONMENT

Several applications of synthetic evaluating results of regional vegetation eco-environment show as follows:

(1) There are macro control effects in the construction projects or the ecological environment evaluation of industry planning. In environmental impact assessment process, evaluation of the ecological environment is the most important content to regional developments, tourism developments, and constructions among roads, railways and ports, projects of planning assessment. The construction projects or the evaluating on present planning ecological environment or environmental impact assessment are on the basic of being acquainted with estimating present state of ecological environment in the whole study area. Synthetic evaluating results of regional vegetation ecological environment may be as the reference context of assessment on present planning ecological environment in evaluating program districts.

(2) The applications of ecological assets and ecological environment worthy assessments. For example, the biological value of production could be applied directly for estimating vegetation biomass in ecological worthy estimation, in addition, economic value will be obtained directly from the market price. The elementary contents of ecological environmental value contains evaluating and conversion of economical worthy method about ecological environmental entity. It may be comprehended to currency inversion; the foundation is assessment of ecological environmental entity.

(1) The applications of ecological environmental functional evaluating. The ecological environmental functions are in accordance with the ecological environmental types, the functions of different ecological environmental types are relative, and they consider the rank value of ecological environmental quality as the certain evidences of function degrees.

CONCLUSION

This paper mainly concerns with the evaluation contents of the theoretical paradigm to ecological environment evaluation. The main conclusions are as follows:

✓ The laws of level distribution to the ecological environment in Fuzhou are: The levels of ecological environment are increasing gradually from coastal to inland; Take the river or its tributaries as the center and expand to their both sides, the levels of ecological environment are also increasing gradually; In the western of study area and the southern of Min river, there is a dendrite zone of the ecological environment increasing, which is the mountain basin or valley of low hills that as the stretches part of Daiyun mountain. There is also a “V”-type area of ecological environment increasing in the eastern of northern Aojiang River; There are some consistent laws between the elevated level of ecological environment of vegetation, the distribution of ecological environment environmental type, topography, and geomorphology, etc.

✓ The conclusions on entropy comprehensive evaluation of the ecological environment to vegetation are: The value distribution of environmental quality rules with trend surface gradient; linear gradient Degree of regularity; weak law of concentric circles, concentric circles around the center of high quality and low quality; terrain leading law; the value of environmental quality and Relativity of time and space law.

✓ The laws on vegetation ecological environmental changing: the distribution rules are similar to the time movement; edge effects; in terms of the same land feature or the profiles of the same value of ecological environment quality, there are certain connections among the values of ecological environment quality of different temporal. The effects of changes of ecological environment can be acquired indirectly according to the related coefficients of the values of ecological environment quality of different temporal. The changes of eco- environment quality is weak when the related coefficient is large; The changes of ecological environment quality is fierce when the related coefficients is small. The wave trend of valley ecological environment enhances from the west to the east.

✓ Assessments on ecological environmental quality of different temporal also can be referred to hatching sampling which is a relative credible test technology for quality evaluating.

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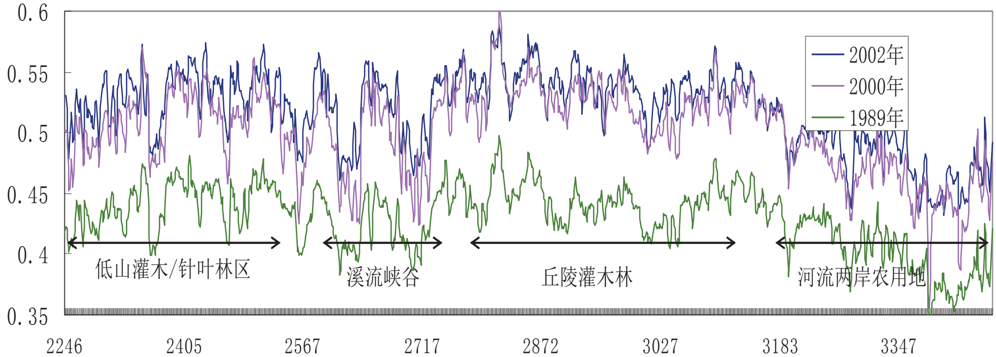

Figure 4. Transverse section map of eco-environment quality in the North (From west to east)

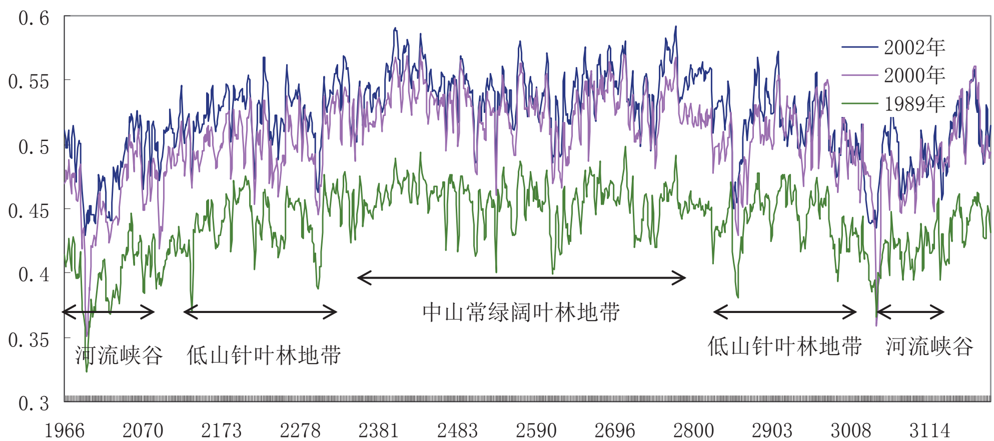

Figure 5. Transverse section map of eco-environment quality in the South (From west to east)

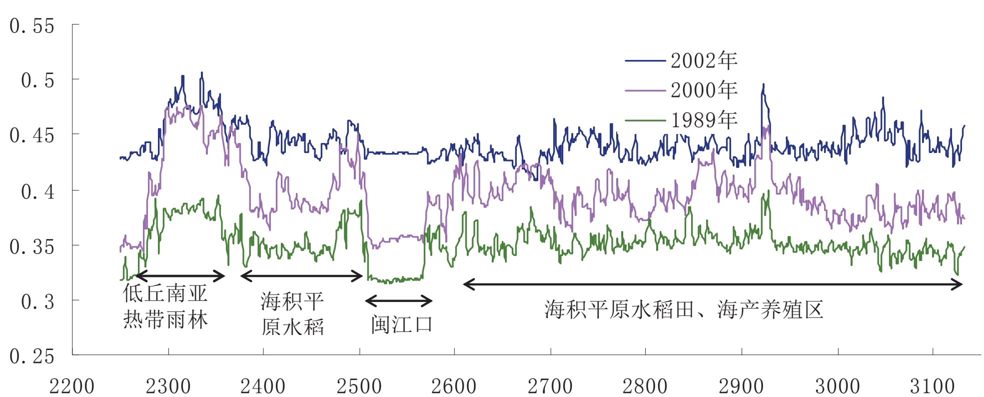

Figure 6. Vertical section map of eco-environment quality in the Eastern Seaboard (Minjiang entrance) (From north to south)

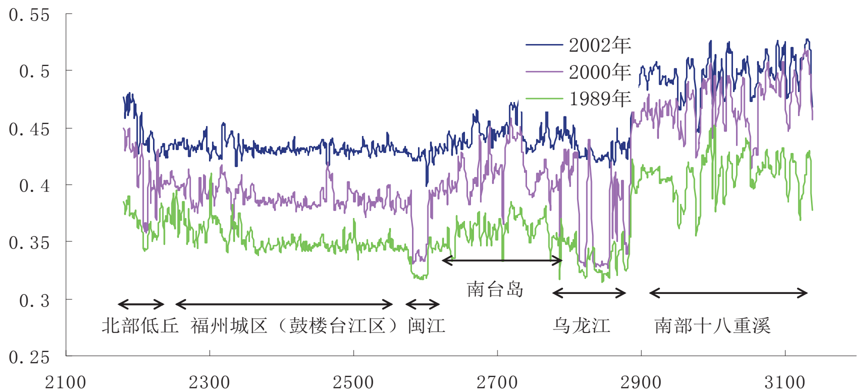

Figure 7. Vertical section map of eco-environment quality in Fuzhou city (From north to south)

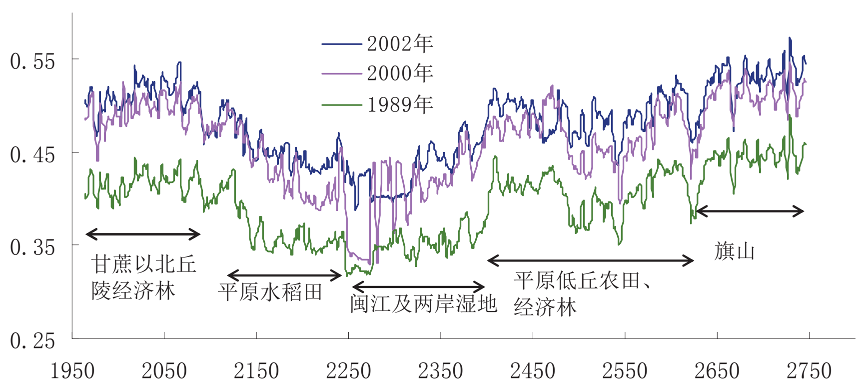

Figure 8. Vertical section map of eco-environment quality in Fuzhou west suburb (Minhou sugar cane town) (from north to south)

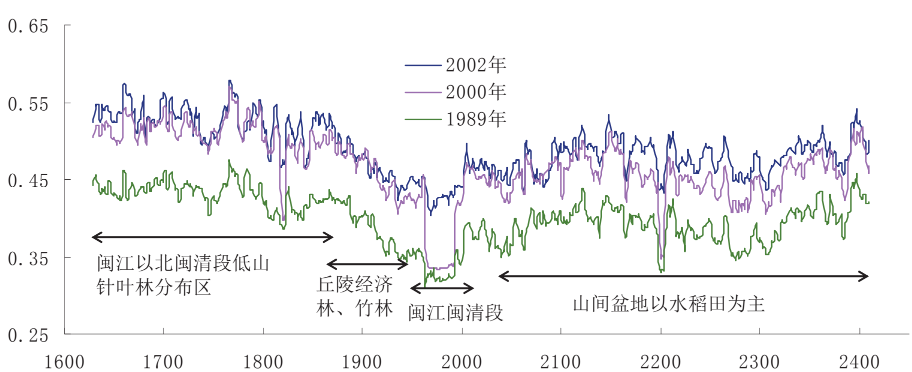

Figure 9. Vertical section map of eco-environment quality in Minqing city (From north to south)