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The application to uncertainty theory due to optimization of regional land-use structure

Xusen ZHU[1], Zhongcheng WANG[*]
School of Economics and Management, Chongqing Normal University, Chongqing 401331, (CHINA)

ABSTRACT

Regional land-use structure directly impacts the economical, social, and ecological benefits of land. This study firstly discussed the research method that needed and constructed the optimized model. Then taking Y city as the object of theoretical hypotheses, we researched the city's land-use structure optimization problems, concluding that the optimized land-use structure is significantly superior to the existing utilization structure. And the method of this study is relatively new and practical, it may has certain reference significance to land planning workers and other scholars who are interested in the topic.

KEYWORDS

Regional land-use; Land-use structure; Uncertainty theory; Structure optimizing.

INTRODUCTION

land-use structure, also called land structure or land formation, refers to the proportion or composition among various land-use structures in a country, a region or a production unit. There are multiple forms of land-use structure, such as the proportion of direct producing land (arable land, pasture, forest etc.), indirect producing space (roads, channels etc.) and unproductive land (desert, glaciers, swamp etc.), the proportion of agriculture, forestry, animal husbandry and fishery industries in the agricultural land. Seen from the definition of land-use structure, it has a strong sense of uncertainty. However, structure affects the function greatly, with a result that we need to optimize the land-use structure so as to max its function in national economy. An important goal of uncertainty theory research is to optimally treat the object of study so that the best decision can be made based on uncertain information. Next, this article will use the theory of uncertainty and its approach to study the problems of land-use structure in our country. The perspective is relatively novel, not only can help land managers to make reasonable plans for land use in elastic range, but also provide reference of methods and point of view to other interested researchers.

RESEARCH METHODS

The composition of the uncertainty factors

The land-use structure is facing many uncertain factors, mainly including uncertain basis factors, uncertain subject factors, uncertain economic factors, uncertain social factors and uncertain ecological factors.

(1) the uncertain basis factor refers to the uncertain data that needed in the optimization of structure. This uncertainty may be caused by statistical work or data changes. It has a fundamental influence on land-use structure optimization. Therefore, it needs strict statistical caliber and statistical standards during the process of land-use structure optimization so that we can ensure the reliability of dates.

(2) the uncertain economic factors refers to the level of economic development. It will change over time, causing effect on land-use structure with the change of industrial structure and investment preferences. This uncertainty is bound with the development of the market economy.

(3)the uncertain social factors refers to the changes of scale of urban development, the advancement of urbanization strategy and population. It has direct impact on cultivated land area, residential area, industrial land area and so affects the land-use structure of urban and rural area.

(4) uncertain ecological factor refers to impact caused by the change of ecological environment. Generally speaking, it includes soil erosion, earthquakes, even the views of forest as well as climate change and so on.

(5) uncertain subject factor refers to the uncertainty of professionalism, planning skills, working status, occupational preferences of land planners (or managers) and individual differences that may affect the optimization results.

The construction of land-use structure optimization model

There are more than one land-use structure optimization goals, so this article will choose economic benefits and ecological benefit maximization as the goal model. At the same time, this article will take social benefits as the constraint condition of the model. There are different algorithms in the situation of uncertain factors which are most likely to occur and the uncertain factors occur in a certain range. the former situation uses the expectation model while the latter one choose random simulation method (there is 80 percent possibility of the uncertainty).

Goals of land-use structure optimization

(1) economic goals. It mainly includes the economic interests of the cultivated land, forest land, the grassland, water area, the economic interests of the rural residential areas, rural industrial added value, tourism economic interests, the land for the economic interests of the mining, transportation, water conservancy, mudflats and other unused swamp (it can be ignored). These interests can be showed by using their added value to represent the interests of per unit area while consumption has been removed in the process of capturing.

(2) ecological goals. They are mainly including ecological interests of cultivated land, grassland and forest, gardening, agricultural land; The benefits of residential areas and mining, transportation, water conservancy and other construction ; ecological benefits of waters and tidal flats and unused swamp land. It is worth noting that the ecological benefit of construction land is negative.

The expectation model

As a common one of the uncertain optimization models, the expectation model can calculate the expected max value in uncertain environment. There are uncertain variables contained in both the objective function and constraint function. There are various methods of calculating the expectation model, therefore,this article will firstly deal with the law of large numbers and uses those calculated numbers into available models that can be calculated by the multi-objective genetic algorithm. Here is the formula (1):

$$\begin{cases} \max[E[F_1(X)]] = \max \sum_{i=1}^{12} E(c_i)x_i \\ \max[E[F_2(X)]] = \max \sum_{i=1}^{12} e_i x_i \\ s.t. E[g_j(X,\varepsilon)] \geq 0, j = 1,2,...,m \end{cases} \quad (1)$$

In formula (1), the meanings of variables are: $F_1(X)$ represents the economic goal of land use, $F_2(X)$ is the ecological goal that to be achieved. The unit of them is ten thousand yuan. x_i means land area, its unit is $hm^2 X$, a vector, which represents the land use structure; c_i is the economic interests of land while e_i shows the ecological benefit, their unit is $ten\ thousand\ yuan / hm^2$; $gj(X,\xi)$ works as constraint conditions, while ξ means uncertainty of these indicators.

Elastic range

This article assumes that the possibility of uncertainty factors in the 80% range. In order to calculate the elastic range within the scope of land use structure optimization, we will use immediately simulation method to forecast. For the future value of uncertainty index, this survey will obtain the distribution by forecasting and researching. When the probability level (elastic range) is 80%, formula (2)will be used to calculate the land-use structure optimization

$$\begin{cases} \max[F_1(X)] = \max \sum_{i=1}^{12} [c_i^L] x_i \\ \max[F_2(X)]] = \max \sum_{i=1}^{12} e_i x_i \\ s.t. E[g_j(X,[\varepsilon^L,\varepsilon^U])] \geq 0, j = 1,2,...,m \end{cases} \quad (2)$$

In formula (2), $F_1(X)$ 与 $F_2(X)$ have the same meanings in formula (1): representing the economic goal of land use and the ecological goal that to be achieved.

Then simulation can be achieved by using the random function. In formula (2), the objective function and constraint function can be cured within the 80% range so that multi-objective optimization can be transformed to the general target optimization. After that, genetic algorithm can complete the first cycle. we can finish calculating the cycle like this. In this way, there are n solutions after n cycles that can be represented like $X = [x_1,\ x_1, ...,\ x_n]$. If the $n = 12$, then the end of this process will be elastic range of land use structure optimization: $[X^L, X^U] = [[X_1^L, X_1^U],[X_2^L, X_2^U],...,[X_{12}^L, X_{12}^U]]$

Multi-objective genetic algorithm (GA)

When using multi-objective genetic algorithm to calculate elastic band of optimized structure, you firstly need to use the law of large Numbers and random function to transform the first and the second category of expectation model into multi-goal model. it is necessary to set the crossover probability as 0.8 when using the genetic algorithm, and the mutation probability should be 0.05. After 1000 times of evolution, the non inferior solution set would be output; Through the calculation the non inferior solution set, the maximum value can be assumed to be the optimal solution of multi-objective calculation. This study will use formula (3) to calculate the total target of overall performance:

$$H_\alpha(X_\beta) = \begin{cases} (N - R_\alpha(X_\beta))^2 & R_\alpha(X_\beta) \geq 1 \\ kN^2 & R_\alpha(X_\beta) = 1 \end{cases}$$
$$H(X_\beta) = \sum_{i=1}^{\alpha} H_\alpha(X_\beta) \quad \beta\text{=1,2,...,N,}\alpha\text{=1} \quad (3)$$

In the formula (3): N, ρ, represents individual number, target number, the sort of the individual on the target, the individual's overall fitness; For the constant k, this study will be set it as 2.

THE EMPIRICAL STUDY OF LAND USE STRUCTURE OPTIMIZATION

The object of study

It takes Y city in jiangsu province as the research object. The city's total area is 6634 square kilometers and has population of about 4.6 million; The municipal district area is 71.9 square kilometers (by the end of 2012), 1.18 million municipal district population (by the end of 2012). If take the ha (hm2) as the unit, by the end of 2012, the total area of land in Y city would be 659100hm2, while agricultural land takes 424900 hm2, 64.47% of the total land area. Construction land takes124900 hm2, accounting for 18.94% of the total area of the land; Unused land takes 109300 hm2, accounted for a total area of 16.59%. Therefore, there are plenty of cultivated land resources and waters. However, the city's rural residential construction is lack of unified planning. Along with the advancement of urbanization strategy, the land use structure need to be further optimized.

The land-use structure optimization

When uncertainty factors are most likely to occur, this study uses the expectation model to calculate the land use optimization structure of Y city in 2020. The parameters in the model only have helps, such as land ecological benefit index is not set to uncertainty index, but only as an indicator helps. For distribution problem of the uncertain indicators, this study establish the initial value by experts assigning points, and then use the law of large numbers to calculate the expected value. As shown in TABLE 1, the expectation is to use the law of large Numbers according to the survey data, containing the uncertain information.

TABLE 1: Results of expected value, the predicted values and interval uncertain calculation ()

Uncertain indexes	Expected value	Predicted value	Interval
economic benefit of cultivated land c1	5.84	6.27	[4.2, 7.21]
Garden economic interests c2	3.97	4.11	[2.92, 5.02]
Forest economic benefits c3	13.00	13.49	[3.91, 15.91]
Other agricultural economic benefits c5	2.05	1.99	[1.81, 2.29]
Urban industrial economic benefits c6	1123.80	1359.99	[924.79, 1342.79]
Rural residential economic benefits c7	18.04	18.24	[16.05, 19.88]
Traffic and water conservancy economic interests c8	1163.02	1359.99	[815.99, 1300.79]
Other construction land economic interests c9	6842.45	9664.48	[5025.53, 9277.9]
Water economic interests c10	6.97	7.63	[4.09, 7.94]
Urban greening rate F	0.04	0.04	[0.04, 0.04]
target population year P/ ten thousand people	452.40	477.29	[393.15, 491.61]
target annual economic quantity Q/ hundred million yuan	9047.39	12580.37	[6290.19, 12580.37]
level of Urbanization δ	0.79	0.88	[0.69, 0.88]
Large area of agricultural land V/ ten thousand hm2	32.68	32.49	[29.89, 34.77]
Unused land W1/ ten thousand hm2	1154.16	1135.98	[956.59, 1408.62]
Unit: ten thousand yuan/hm2			

Next, in order to find out optimization goal of city land utilization, the maximum function of economic benefits, ecological benefits maximum function and constraint conditions, let us do the following operations:

(1)optimizing goals

As shown in TABLE 2, the ecological benefits value of land-use structure can be positive or negative, which are decided by the result of different types of land area and economic interests. And the economic interests of the different land-use types can be shown in TABLE 1. TABLE 1 and TABLE 2 show the economic interests of the very thick value (expected) as well as ecological benefit is the first type of land use structure optimization goal.

TABLE 2 : The size of the ecological benefits of different land units

Ecological benefits of land use patterns	Ecological benefits value / $10^6 Yuan \bullet hm^2$
cultivated land ecological benefits	0.61
Garden ecological interests	1.27
Forest ecological interests	1.93
Other agricultural land ecological interests	1.27
Urban industrial land ecological interests	-2.11
Residential land ecological interests	-2.11
Water and land transportation ecological interests	-2.51
Other construction land ecological interests	1.20
Waters ecological interests	4.07
Swamp ecological interests	5.54
Unutilized land ecological interests	0.04

(2)the constraint conditions of the optimization

the constraint conditions that Y city faced are including the future population, economy, and land policy of intensive utilization, the constraints of the food security and ecological protection as well as the resources and environment capacity. These constraints also presents uncertainty with the change of the uncertain environment. This study has specific constraints as follows:

(1) total area under the constraint conditions as:

$$\sum_{i=1}^{12} X_i = A$$

In this type, Y city's total land area is presented as A (hm2). According to the statistical data of this study,it will be assigned as 65.91 hm2

(2) the cultivated land area under the constraints as:

$$X_i \geq G$$

The G means the bottom line of the cultivated land protection in the city, according to the requirement of the land conservation planning of Y city in jiangsu province, it will be assigned as 31.44 x104hm2.

(3) urban green land area is controlled by:

$$[x_9 / (x_6 + x_9)] \geq E(F)$$

F shows the proportion of the land used for tourism, E (F) stands F expected value, assigned as 0.04.

(4) development intensity under constraint conditions as:

$$\left[(x_6 + x_7 + x_8) / A \right] \leq PR$$

PR is Y city land development intensity, according to the city's overall land use planning, assigned as 19.26%.
economic development under constraints as :

$$x_6 \geq \frac{E(Q)}{l_1}, X_8 \geq \frac{E(Q)}{l_2}$$

Q stands Y city's annual economic target, unit as one hundred million yuan; E (Q) is expected value of Q, assigned as 9047.39; L1 and L2 shows output peak (unit is $/ hm2), transportation, water conservancy lands output (unit is $/ hm2), the former one assigned as 0.3 while the latter value as 0.51.

(5) population under constraint conditions as:

$$x_6 \geq E(P) \times E(\delta) m_3, x_7 \geq E(P) \times E(1-\delta) m_2$$

P stands the city's annual target population size (unit: ten thousand), E (P) shows its expected value, assigned as 452.4; m_1 stands the city's minimum area of urban land per capita (unit: m2), assigned as 60; M2 stands the city's rural minimum living area per capita (unit: m2), assigned as 100.

(7)land intensive utilization under constraint conditions as:

$$x_6 \leq E(P) \times E(\delta) m_3, x6 \leq E(Q) / l_3, x_7 \leq E(P) \times E(1-\delta) m_4$$

M3 stands the city's highest standards of land for urban per capita (unit: m2), assigned as140; The m4 stands the highest standard of the city's rural per capita land (unit: m2), assigned as 160;

(8)macro land use plan under constraint conditions as:

$$(x_1 + x_2 + x_3) \geq E(V)$$

V says the city's agricultural land in the area (unit: hm2), assigned as 32.68 in this study.

(9)The ability of land supply under constraint conditions as:

$$E(W_1) \le x_{12} \le W_2$$

The lower limit of the unused land (unit: hm^2), unused land cap (unit: hm^2), the former one assigned as 770.31, while the latter one is 154.16.

(10)other constraints:

$$x_9 \le h_9, x_{10} \le h_{10}, x_4 = 0$$

It says the upper limit (unit: hm2), as 0.28 and the city's water cap (unit: hm2), as 18.1.

(3) the optimization results and analysis

For the optimization of land use structure in the (2), 10 non inferior solution could be set after 100 iterations of multi-objective genetic algorithm (ga). As discussed above, through comparison one of the largest fitness value of these non inferior solution set will be used as the optimized structure of the category 1 land (uncertain factors are most likely to occur). Through the calculation of multi-objective genetic algorithm (ga), as shown in TABLE 3, the city's economic benefit value in 2020 is ten thousand yuan, and its ecological benefit value showed as ten thousand yuan. After comparing the existing general plans for land utilization value, the corresponding values in TABLE 3, we found that the two optimized indicators are higher than expected for the city's existing general land use planning. it is proved that the land use structure after optimization is tend to be more reasonable.

Compared with the present situation of land-use structure, there is obvious improvement in the optimized land-use structure of farm land for residential areas, cultivated land and forest land. the existing cultivated land area in Y city is 284100 hectares, still far from the index of cultivated land protection planning of jiangsu province. the existing forest land area (05100 hectares) are much lower than the optimized woodland area (12700 hectares), indicating that the city will face a difficult task in terms of increasing the forest area. the optimal structure of the land area is 46400 hectares while the existing mining area is 3,69 hectares, therefore,those land can be used for the future urbanization. After optimization, the city's rural residential electricity area is 13000 while the exiting one is 64400 hectares, as a result of the rural population decreasing and the residents efficiency improvement.

TABLE 3 : Optimized land use structure of Yangzhou in 2020 when uncertainty factors are most likely happened

	Current structure	Planning structure	Optimum structure
Cultivated land /ten thousand hm^2	28.41	31.44	31.47
Garden land /ten thousand hm^2	1.31	1.02	1.17
Woodland /ten thousand hm^2	0.51	1.93	1.27
Grassland /ten thousand hm^2	0	2.16	0
Other agricultural land /ten thousand hm^2	4.93	2.82	4.52
Town and industrial land /ten thousand hm^2	3.69	3.79	4.64
Rural residential land /ten thousand hm^2	6.44	6.11	1.30
Traffic and water conservancy land	2.01	2.79	2.28
Other construction land	0.19	0.30	0.26
Water land	17.24	14.23	17.89
Beach and marsh land	1.12	1.38	1.09
Unutilized land	770.31	952.8	207.7
Economic value /Yuan	$8.2*10^{11}$	$9.9*10^{11}$	$10.0*10^{11}$
Ecological value /Yuan	$7.64*10^{11}$	$6.58*10^{11}$	$8.98*10^{11}$

CONCLUSION

Based on the study of land-use structure optimization through uncertainty theory, China can use multi-objective genetic algorithm (ga) during the process. The uncertainty factors of land-use can be divided into uncertain body factors, the basis of uncertain factors, economic factors of uncertainty, the uncertainty of social factors and ecological factors of uncertainty. The expectation model can be transformed into general multi-objective optimization model by putting the expectations index into model through multi-objective genetic budget, obtaining the land-use structure optimization of the elastic range and after simulation. With Y city as an example of empirical study of this research not only proves the method is feasible, but also can be based on the comparison of fitness for all sorts of different land-use projects. The method is novel, rigorous and persuasive, and future research can be more in-depth research scope, the respect it as the research target.

REFERENCES

[1] K.Iwao, K.Nasahara, T.Kinoshita, Y.Yamagata, D.Patton, S.Tsuchida; Creation of New Global Land Cover Map with Map Integration, Journal of Geographic Information System, **3(2)**, 160-165 **(2011)**.
[2] K.Iwao, K.Nasahara, T.Kinoshita, Y.Yamagata, D.Patton and S.Tsuchida; Creation of New Global Land Cover Map with Map Integration, Journal of Geographic Information System, **3(2)**, 160-165 **(2011)**.
[3] Amin, S.Fazal; Land Transformation Analysis Using Remote Sensing and GIS Techniques (A Case Study), Journal of Geographic Information System, **4(3)**, 229-236 **(2012)**.
[4] Y.Guo, X.Huang, J.Peng; Using GIS to Analysis Runoff Change in Land Utilization of Foping, Nature Reserve, Shanxi Province, Journal of Geographic Information System, **1(1)**, 48-52 **(2009)**.
[5] W.Liao, S.Xu; Study on Provincial Land Use Database Remittance Standard Establishment, Journal of Geographic Information System, **2(2)**, 120-123 **(2010)**.
[6] H.Wang, C.Zhao, M.Xiaokaiti, Y.Zhou, R.Zhao; Dual Land Market and Rapid China’s Urbanization: Problems and Solutions. Chinese Studies, **1**, 1-4 (2012).
[7] W.Liao, S.Xu; Provincial Land Utilization Database Construction Analysis, Journal of Geographic Information System, **1(1)**, 22-25 **(2009)**.
[8] J.McDonald; A Model of Mixed Land Use in Urban Areas, Theoretical Economics Letters, **2(1)**, 94-100 **(2012)**.