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Research on Change Monitoring Method of Cultivated Lands Level Based on Volatile Indicators

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Abstract: With the second national land survey carried out, land grading method is nearly mature, but change monitoring of cultivated lands level has not yet been proposed an effective method. The paper makes the second national land survey as research basis for change monitoring. According to the differences of indicator monitoring periods, authors introduce the concept of volatile indicators. Change monitoring indicators are divided into volatile and non-volatile indicators. This way updates non-volatile indicators only when monitor can improve the efficiency of monitoring. For the region data is missing, this paper suggests filling the missing data through spatial correlation. In order to unify monitoring units, authors propose a new method- Be post-grading units as monitoring units, convert pre-grading values to post-grading units by area-weighted. Finally, we analyze the monitoring result by calculating the quantity, quality, layout, production levels and other aspects. The analysis will play a role in early warning for the quality of cultivated land.

Key Words: Cultivated Lands Level; Change Monitoring Method; volatile indicators; Grading Unit; Change analysis.

1 Introduction

Quality of cultivated land means the sum of natural factors and environmental conditions what constitute the land, which shows the level of production capacity and product quality and the merits of environmental conditions of arable land [1]. The level of cultivated lands is one of the critical factors which reflect its quality. Change

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monitoring of cultivated lands can accumulate the relevant information and improve the content of the land resource management and also achieve the changes from the number of management to the quality and quantity management. Through long-term monitoring, with other relevant knowledge, analyze the monitoring results in all aspects and study the trends in land levels. The analysis can support land management science to decision-making.

In the second national land survey process, it has formed a set of relatively mature methods of Agricultural Land Classification system, but how to monitor the change of cultivated lands has not yet made a systematic approach. This paper combine he knowledge and previous research about grading for dynamic monitoring of Quality of cultivated land, and propose a new set of change monitoring method of cultivated lands level. Finally, we carry out a systematic analysis to achieve the quality of cultivated lands early warning role.

2 Current Situation of the Research

The methods of cultivated lands level's change monitor commonly use time-series model analysis combined with analysis of influencing factors. By comparing land grading indicators of different periods, reveal the variation of cultivated lands level and characteristics, combined with the variation of the factors and trends, forecasting the direction of the evolution of land level [2]. Chinese cultivated land soil survey started in 1985, but rapid progress. With development of computer and spatial technology, dynamic monitoring method of cultivated lands quality based on 3s technology has been used widely. This method completes land quality monitor using automatic discovery of computers and technology of overlay analysis with the RS, GIS, GPS and other software tools, and the data basis are remote sensing images, soil images and other data [3]. The second national land survey has done a lot of works in evaluation of land level, which provide a theoretical basis for monitor and data protection for future monitor in land levels. Peng Ru-yan and Zhang Xiao-pei [4] make the agricultural land classification rules as a basis, from the principle of the monitoring points' layout, monitoring index system, monitoring data collection, evaluation of monitoring results and spatial information technology, five-pronged approach, initially built national quality of cultivated land dynamic monitoring system which provide basis for China's cultivated land resources conservation and management decision for the future.

3 Research of Change Monitoring Method of Cultivated Lands Level

The assessment of cultivated lands level is premise of change monitor, "Agricultural Land Classification Regulations" [5] (Later referred to as "Regulations") clearly defines agricultural land classification process, as figure 1 shown, the whole process can be briefly summarized as: Target areas identified —>Grading unit

identified—>Grading factors identified—>Index calculation—>Determine the level—>Summary acceptance.

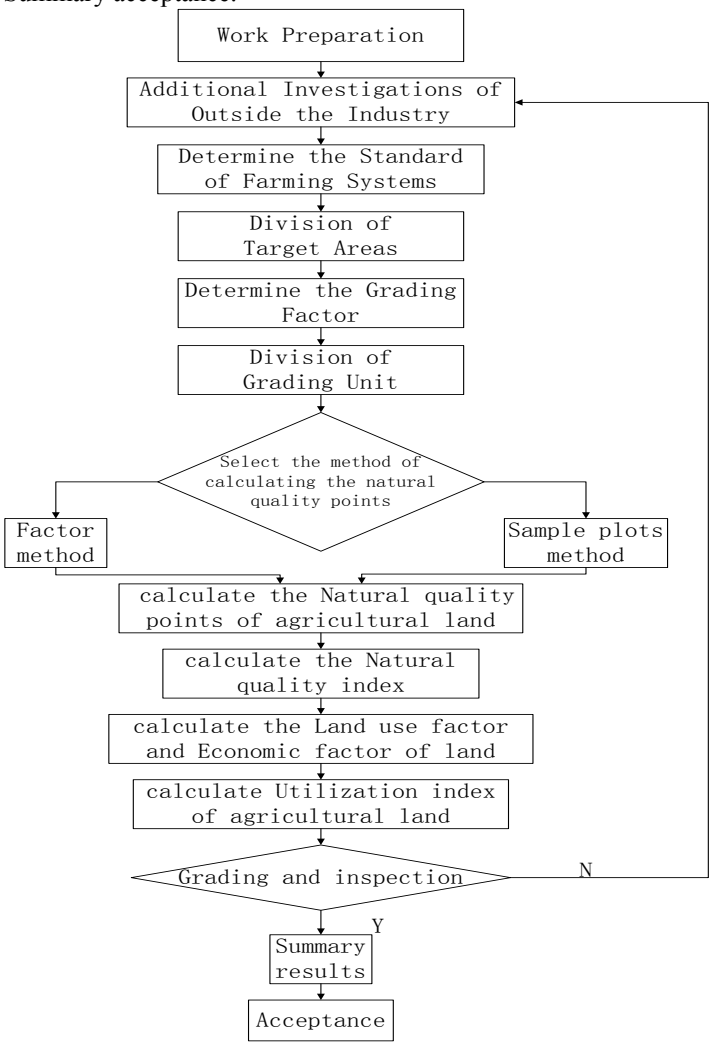

Fig. 1. Agricultural Land Classification Process

3.1 Volatile index and non-volatile index

Level of agricultural land is affected by natural factors and socio-economic factors. Natural factors include climate, topography, soil, water, etc. Socio-economic factors include the socio-economic environment and geographic conditions, etc. In the "Regulations", all these factors are taken into account. All of the above factors will change with time. However, due to the intensity of driving force which makes them change is different, some factors change slowly and some are not. On this point, this

paper introduces the concept of volatile index and non-volatile index. Volatile index is the indicators which are significant changes in agricultural land quality when driven forcefully in a short time, such as the status of land use. Non-volatile index refers to which can maintain a relatively stable index over an extended period in natural state [6], such as soil type. Different indicators have different change periods, and the same indicators at different index areas, the periods probably are different. Based on the differences of change monitoring scope and extent in land quality levels, monitoring cycle is divided into three categories: Regular monitoring: monitor and evaluate various indicators those cause cultivated land quality level changes, monitor once every three years. Real - time monitoring: monitor and evaluate various changed indicators caused by various types of engineering measures in the "increase, reduce, establish" process, monitor once every one year. Immediate monitoring: monitor and evaluate various changed indicators those caused by unpredictable natural and man-made destruction. It is measured only when the land level monitoring database changed .In practical application, it should set the change cycle based on the difference of driving forces which promote indexes changed in target area. Change monitoring gets the change information by comparing two cultivated grades. It also has a certain periodicity. If this cycle is less than the change cycle of the evaluation, these indicators can be seen as non-volatile. Others are volatile indexes which should be graded by the updated data. This rapid detection method can greatly reduce the workload of data collection and improve the efficiency of grading and monitoring. However, this method can not apply to mutated region, such as level evaluation and monitoring of land reclamation and development region. As figure 2 shown, this article will be divided into two kinds of areas-mutative and gradient regions-to monitor.

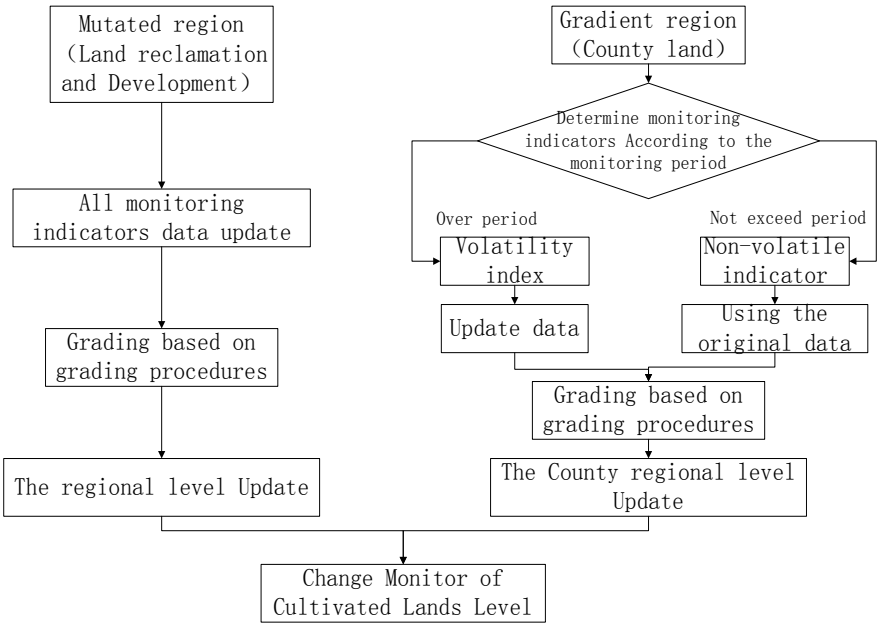

Fig. 2. Differences between mutations and gradual region in grading

3.2 The changes monitoring process based on spatial correlation

For the areas whose evaluations almost are known, it is desirable that combines with the concepts of volatile indicator and non-volatile indicator to grad. But if some areas are not able to acquire such these evaluation indexes or the data are missing, this method will be out of function.. For such problems, this paper proposes a level estimation method based on spatial correlation. We can use neighboring cells whose levels are known to estimate the levels value of the unknown elements through the spatial interpolation. In practice, on the basis of the characteristics of the data, we can select different interpolation methods for interpolating. It is worth to note that the level of mutations in the region can't be estimated by this method because the level does not have the continuity with the adjacent areas' level. For change monitoring, there are two different estimation methods: The first, according to the two period levels' difference of adjacent units, we can directly estimate the level of change in the value of the unit. This method does not involve any period level of the unit, so this method is applicable to this condition that two period levels of adjacent units are known in the two period levels. The second, according to the second period level of adjacent units, we can estimate the unknown value of the after-changed unit, and make use of the difference between the estimated level value and the before-changed level value to acquire the value of grade changes. This method is suitable for the first period level of the estimated unit which is known. Due to the change monitoring is carried out on the basis of the second national land survey, the first period level of all units is known. In theory, the two methods are reasonable and practical. But in order to take full advantage of the known conditions to reduce the estimation error, this paper introduces the second method to estimate the unknown value of the second period level of the unit. When only a few indicators are missing, interpolation for index data is also feasible. We can specify a threshold value "n". When the number of missing data is greater than the index n, it is considered to directly operate on the level. On the contrary, it is considered to interpolate for these missing indicators. General process is shown as Figure 3.

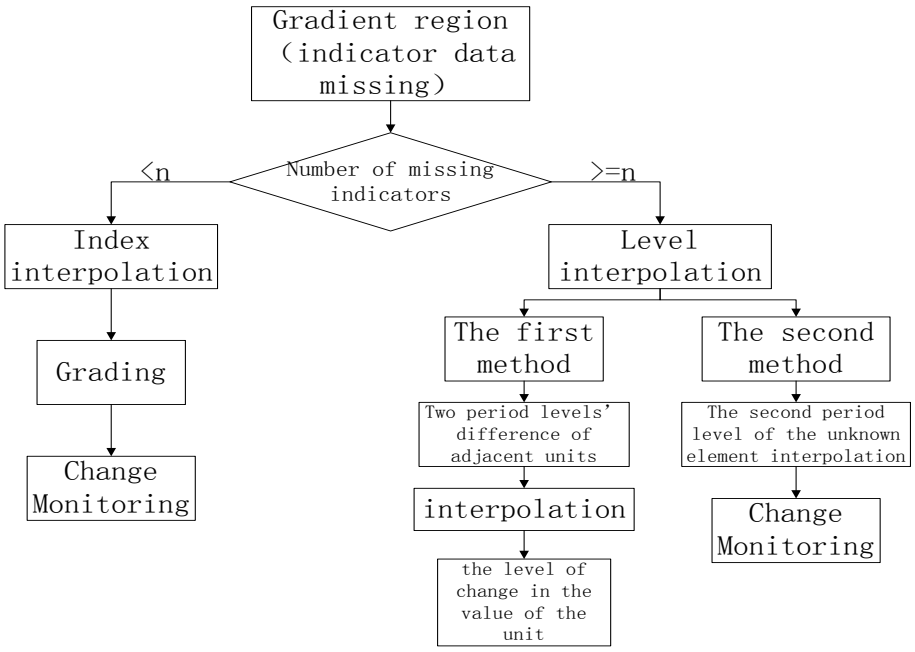

Fig. 3. Change monitoring process based on spatial correlation

3.3 The method research for the unity of change monitoring units

According to "Regulations", the division of agricultural land grading unit includes four ways: Overlay method: Land use map, topographic maps and soil maps in the same scale are superimposed, through this way it can be formed a new layer, the new layer can be seen as grading units layer; Land block method: Directly using polygons of the land use map as the grading units; Grid method: grids with certain sizes are used as grading units; Polygon method: All grading factor maps are superimposed. In these four methods, the second one-land block method-is common to use, but there is a problem for change monitoring: Assuming that we monitor the land level change between 2007 and 2010, grading units in 2007 are based on 2007 land use map, and grading units in 2010 are based on the 2010's, but the two land use maps can't be exactly the same, there is the case that the two period grading units do not correspond. So these units cannot be directly used in change monitoring. We have to make the two grading results correspond to each other in grading units. To facilitate the description, the grading result of an earlier phase is called pre-grading result. The later result of the grading is called post-grading result. No matter what technology is used to convert the arable land grading results, the law of natural grad ,using grad and economy grad after conversion must reflect the actual of regional resources and must match the distribution of regional characteristics about the light, temperature, soil and water[7-10]. The approach is as follows: post-grading units are seen as basic units of change monitoring. Making the area as converted weight, pre-grading result is transformed into post-grading unit. As figure 3 shown, shaded area is one of post-grading units which steps over the four pre-grading units. The numbers in the figure are the levels

of pre-grading units. In addition to cultivated land, other land types' levels assign to "0".We calculate pre-grading level of the shaded unit by the ratio between area of intersection and the pre-grading level. This method can get two different time (Pre-grading and post-grading) levels at the same grading unit. The two values can be seen as two property value fields of change monitoring unit data. There are three levels in grading: natural grad, using grad and economy grad. In attribute table, we name them as "The value of pre-natural grad", "The value of post-natural grad", "The value of pre-using grad", "The value of post-using grad", "The value of pre-using grad" and "The value of post- economy grad", then post-grading value subtract pre-grading value, we can get the changed grading value. Add three fields to attribute table: "Changed natural level", "Changed using level" and "Changed economy level". When change in level is equal to 0, it means no change in grading unit level; when change in level is greater than 0, the land levels increased, indicating quality of arable land improved; when change in level is less than 0, the land levels decreased, indicating quality of arable land declined. About the judgment for new arable land, non-cultivated land's polygon of pre-data and cultivated land's polygon of post-data seek common ground by ARCGIS software. The common ground is the new arable land. About the judgment for disappeared arable land, non-cultivated land's polygon of post-data and cultivated land's polygon of pre-data seek common ground by ARCGIS software. By calculating the new land and the disappearance of arable land area, we monitor changes in the amount of cultivated land. **B**y monitoring changes in levels, we can monitor changes in land quality, so as to achieve double control- the quantity and quality of arable land.

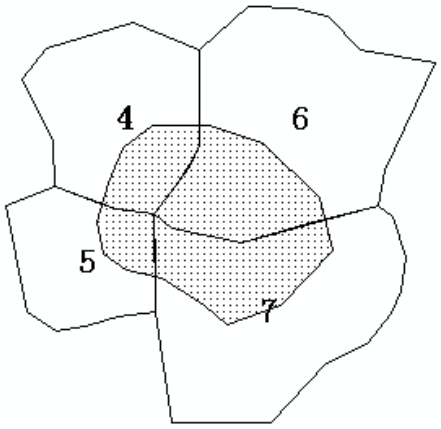

Fig. 4. Conversion figure of pre-grading result

4 The Analysis of Monitoring Results

Analysis for monitoring result is also very important. According to "Pilot monitoring land quality grade Technical Manual" [11], as shown in figure 5, the main

change analysis can be divided into four parts: change analysis on arable land level, mutation analysis on arable land quantity, changes in the layout analysis and analysis of changes in the level of production capacity. The changes of number and grade have been analyzed in Section 3.3, this section will mainly analyze changes in the layout and production capacity.

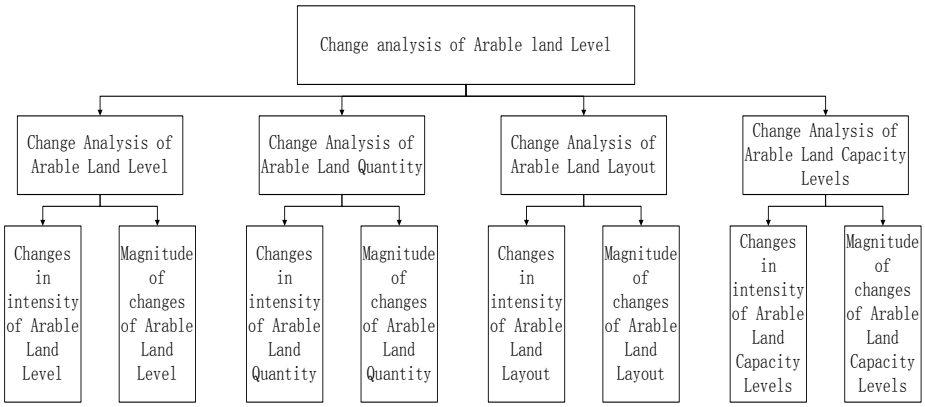

Fig. 5. Process of Change analysis of land level

Spatial layout can be measured by plaque fragmentation index of regional cultivated land "FN". "FN" can be calculated by "Np" and "Nc", "Np" is the total plaques of regional cultivated land and "Nc" is the ratio of cultivated land's total area and the smallest plaque area of the region. Specific calculation is as shown formula 1:

$$FN = \frac{N_p - 1}{N_c} \quad (1)$$

The change of spatial layout can be reflected in the intensity "SFN" and the margin "EFN" of regional cultivated land's plaque fragmentation. "SFN" can be calculated by plaque fragmentation index of regional cultivated area as formula 2 shown:

$$SFN = \frac{FN_n}{FN_{n-x}} \quad (2)$$

In formula 2, "FN_n" means regional cultivated land plaque fragmentation index of year n, "FN_{n-x}" is regional cultivated land plaque fragmentation index of year n-x. "x" is the discrepancy between two monitoring periods. "EFN" can be calculated by formula 3:

$$EFN = FNn - FNn - x \quad (3)$$

SFN> 1, which indicates the fragmentation degree of arable land is increased; SFN=1, which means there is no change in fragmentation; SFN<1, indicating the degree of fragmentation of arable land is decreased. The elevation of fragmentation, is not conducive to field management and mechanization, and indicates that the adjacent

land probably has been destructed. From a regional point of view, the overall quality of arable land is decreased.

Like the spatial layout, change analysis of arable land capacity levels is also based on regions. The change intensity of the arable land capacity is calculated by formula 4:

$$SW_i = \frac{w_{i,n}}{w_{i,n-x}} \quad (4)$$

In formula 4, "SWi" is the change intensity of arable land capacity of region i. "Wi,n" is the arable land capacity level of region i, year n. "x" is the monitoring period.

The Magnitude of arable land capacity change is calculated by formula 5:

$$Ew_i = w_{i,n} - w_{i,n-x} \quad (5)$$

Obviously, when SWi>1 or EWi>0, it means the capacity was improved; when SWi=1 or EWi>0, it means the capacity has no change; and when SWi<1 or EWi<0, it means that the capacity was decreased. Zhang Qingpu et al [12] in the study "National agricultural land grading distribution law based on conversion from provincial level to national level in Chongqing" proposed that natural level indices, utilization index and economic index of Chongqing municipal agricultural land have linear correlation with the actual standard grain yield. That means, the capacity and quality of arable land has a direct relationship, so we can forecast trends in land quality through the change of capacity.

5 Conclusion

(1) Based on monitoring period, the concept of volatility index and Non-volatile index can be pointed out, which can greatly reduce the workload of data collection and improve the efficiency of grading and monitoring.

(2)This paper proposes to interpolate evaluation or rating value in order to obtain the unknown data by the spatial correlation of the data, and chooses different methods to operate on the basic of the characteristics of the data.

(3) It is the prerequisite for change monitoring that integrates the two periods' grading units. Pre-grading result is transformed into post-grading unit with the area for weight, and regards post-grading unit as basic unit of change monitoring. Through this method, the prerequisite can be achieved. Theoretically, both ensuring the uniform of two periods' grading units, and avoiding the situation that monitoring units and the latest land use map do not correspond.

(4) Analysis of monitoring results is very important for quality of cultivated land. Through analyze the quantity, quality, layout, production capacity and other changes, analysis of monitoring results can be used to forecast trends in cultivated land quality, which play a role of early warning for land quality.

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