Discussion of Management Information System of Sloping Farmland in Three Gorges Reservoir Region

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Abstract: Three Gorges Reservoir region are leading soil erosion region in the upper reaches of the Yangtze River basin. Sloping farmland is the source of severe soil erosion. As a way of erosion control, this paper put forward management information system of sloping farmland. In this paper its flow chart, the foundation of database, parameter confirmation, its realization and program design are discussed in detail.

Keywords: three gorges reservoir region, sloping farmland, management information system, flow chart, database, program design

Premier of China Zhu Rongji pointed out that fundamentality of Western China Development was protection and construction of ecological environment while he surveyed and inspected the western region in Oct. 1999. It is only under the condition of ecological environment improvement that abundant natural resources in western region would be exploited and utilized. "National Ecological Environment Construction Programming "approved by China State Department illustrates that soil erosion was the main characteristics of ecological environment deterioration and the major target of ecological environment construction was soil and water conservation. This programming demands to control soil erosion and increase 0.6 million km^2 of erosion control area in 2010. In this programming more than 60% soil erosion region will be controlled and ecological environment deterioration will be prevented in 2030 and most soil erosion region will be controlled and ecological environment will have a great improvement in 2050.

There are 130 million hm^2 farmland in China, one-third of which are sloping farmland. Sloping farmland is the source of soil erosion. Along with severe soil erosion, Fertility loss occurs, which results in water pollution and debases water quality in ecosystem. The upper reaches of Jinsha river basin, the middle and lower reaches of Jialing river basin and Three Gorges Reservoir region are primary soil erosion region in the upper reaches of Yangtze river. Total area of these regions is 0.351 million km^2. The land cultivation rate is 24.9% in these regions, farmland area is 8.75 million hm^2, in which sloping farmland is about 5.49 million hm^2 and steep sloping farmland with $\geqslant 25°$ gradient reaches 1/5 of all sloping farmland. Sloping farmland especially steep sloping farmland is the source of river sediment and cause of water pollution in the lower reaches of Yangtze River. Experts estimates the total soil loss of sloping farmland is 380 million ton in primary soil erosion region of the upper reaches of Yangtze River. In Three Gorges Reservoir area annual soil loss of woodland, shrub land, grassland and sloping farmland is 6.19%,10.76%,23.5% and 60% of total soil loss, respectively according to investigation. In which sediments from sloping farmland accounts for 41.16% of total sediments entered into the Yangtze River. So Three Gorges Reservoir region is major soil erosion control district of the upper reaches of Yangtze River in "National Ecological Environment Construction Programming". The status of ecological environment of this area will directly influences the safety of Three Gorges Reservoir Project and sustainable development of the Yangtze River basin. The focal point of ecological environment construction of the upper and middle reaches of Yangtze River basin is comprehensive control of soil erosion.

1 Distribution and present utilization situation of sloping farmland in Three Gorges Reservoir region

1.1 Distribution of sloping farmland in Three Gorges Reservoir region

Three Gorges Reservoir region located in the juncture of middle and low mountain canyon and low hilly mountain among Chongqing municipality and Hubei province. In these area there have complicated geologic and geomorphic structure and high mountain ridges and undulating hills . Also the precipitation is intensive, Annual precipitation is 1,140—1,200mm but its distribution is not uniform. Most of rainfall happens from May to October, accounting for 85%—88% of yearly rainfall.

In Three Gorges Reservoir region mountainous land is about 97.3% of total land. Total farmland is 2 million hm^2 , in which purple soil farmland accounts for 78.7%. Steep sloping farmland with ≥25° gradient is about 25% of total farmland. Most of sloping farmland distributes on mountainous land. For example, Steep farmland with ≥25° gradient is about 76% of total farmland in Yunyang county and average land gradient in Badong county is 28.6°. Slope land cultivation is the cause of severe soil loss in this region.

1.2 Soil erosion status of sloping farmland in Three Gorges Reservoir region

The essential reason of severe soil loss in Three Gorges Reservoir area is stressful environment capacity. Average farmland is less than 0.067 hm^2 per person and population density is 300 person per km^2 in this region. Erosion types of sloping farmland are classified as gradually erosion and eruptive erosion. Gradually erosion is the major factor influencing sediment yield. Eruptive erosion is the minor factor influencing sediment yield but may result in severe damage. For example, sometimes soil on steep sloping farmland may almost be washed away as a result of eruptive erosion caused by short time, intense rainfall.

The gradient of most sloping farmland is 10° — 15° in Three Gorges Reservoir region, Steep farmland with ≥25° gradient is about 35% of total farmland. According to observation, the increase of 5° on gradient may bring on increase of 6.15 t/hm^2 — 20.1 t/hm^2 of soil loss. Generally speaking, most erosion intensity of sloping farmland is light or moderate in this region, intensive erosion only occurs in few place. Annual sediment yield on sloping farmland is 80 million ton in this region.

2 Discussion of management information system of sloping farmland in Three Gorges Reservoir region

Severe soil erosion on sloping farmland induces soil fertility depression and ecological destruction, which threatens sustainable development of agriculture and the safety of Three Gorges Reservoir Project. As a way of erosion control, this paper will discuss how to design and establish management information system of sloping farmland .

2.1 Flow chart of management information system on sloping farmland in Three Gorges Reservoir region

Flow chart of management information system is as below(Figure 1):

In order to reduce difficulty of basic data collection, the system considers soil type map and land use map as base map in Three Gorges Reservoir region. Because it is difficult to display so much chart spot of sloping farmland in detail, so the system considers to partitive display chart spot on map according to soil type map.
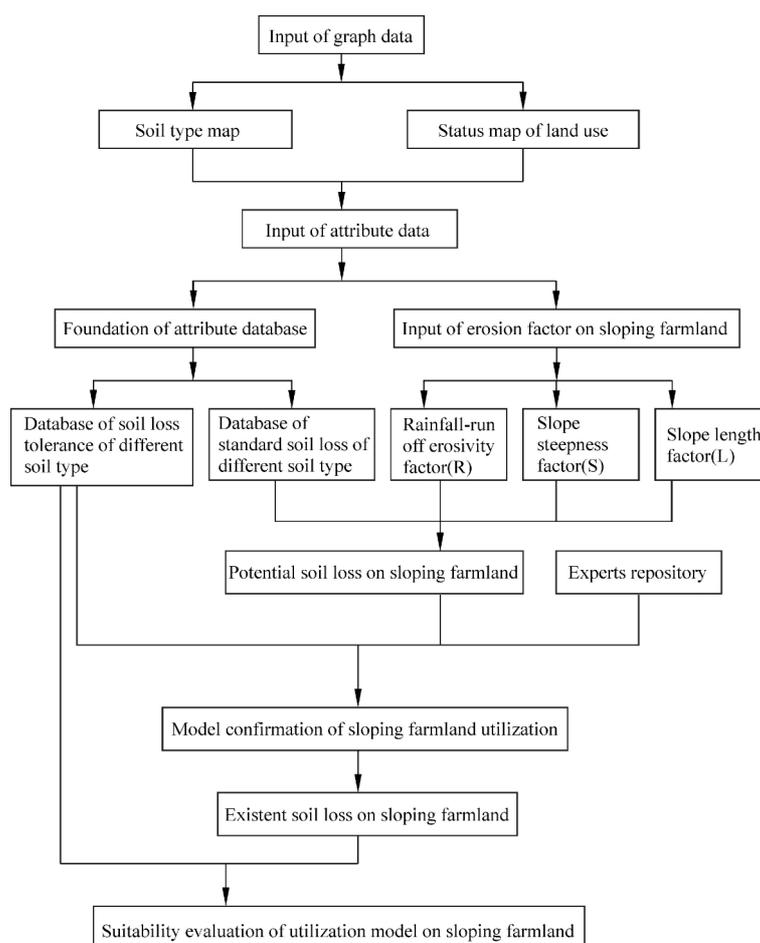
Fig.1 Flow chart of management information system

2.2 Database foundation of management information system and parameter confirmation on sloping farmland

2.2.1 Database construction of maximal soil loss tolerance of different soil type

The definition of maximal soil loss tolerance is allowable maximum of soil erosion while soil loss velocity doesn't exceed soil formation velocity. There have a great difference on soil formation velocity due to different soil type and climate. According to estimation of soil scientists, under natural condition of no-disturbance, 25mm surface soil layer may be formed every three hundred years. Because of cultivation disturbance on sloping farmland, soil formation time may be shortened from three hundred years to thirty years. The soil formation velocity is about 11.2 $t/(km^2 \cdot a)$. Soil loss tolerance not only greatly correlates with soil formation velocity but also with soil condition. For example , 25mm soil loss on thick soil layer may have a little influence on soil productivity but may greatly degrade soil productivity of thin soil resulted from hard rock. According to natural condition in our country, soil loss tolerance is about 2 $t/(hm^2 \cdot a)$ —10 $t/(hm^2 \cdot a)$.

2.2.2 Foundation of standard database of soil loss in different soil type

Standard soil loss in this system is the yield of soil loss in standard small plots(22.1m length and 9% slope steepness) under definite rainfall-runoff erosivity(R). Standard soil loss in Three Gorges Reservoir region may be determined through experiments.

2.2.3 Establishment of experts repository

It is a difficult course to establish a experts repository. The contents of experts repository in the system includes the value of PC_1 under different land use of different soil type and gradient, which may be obtained through experiments and lots of data collection. While setting slope steepness, sloping farmland is classified as six level , which is 2° — 5°,5° — 10°, 10° — 15°, 15° — 20°, 20° — 25°, > 25°, respectively.

2.2.4 Calculation of potential soil loss on sloping farmland

Formula of potential soil loss(A_1) is as below:

$$A_1 = A_0 \times \frac{R_1}{R_0} \times LS$$

Where

A_1: potential soil loss(t /(hm^2 · a))
A_0: standard soil loss of definite soil type(t /(hm^2 · a))
R_1: the value of average rainfall-runoff erosivity
R_0: the value of rainfall-runoff erosivity in experiments of standard soil loss
LS: length factor and slope steepness factor
Formula of LS is as below:

$$LS = \left(\frac{Y}{22}\right)^{0.3}\left(\frac{a}{5.16}\right)^{1.3}$$

Where

Y: slope length of sloping farmland(m)
a: slope steepness of sloping farmland

2.2.5 Selection of land use model of sloping farmland

Selection of land use model of sloping farmland is determined through the value of PC. Formula of PC is as below:

$$PC = \frac{A_1}{A_2}$$

where

A_1: potential soil loss of sloping farmland(t /(hm^2 · a))
A_2: maximal soil loss tolerance(t /(hm^2 · a))

The value of PC on a definite sloping farmland may be calculated through above formula. Compared with the value of PC_1 in experts repository, we may evaluate land use on sloping farmland and put forward rational land use model. In this system there have some selective land use models which include contour tillage system, terrace system, biological covering system, net strip and ridge tillage system, contour vegetation dam system, returning farmland to forest system etc. In our system land use model of sloping farmland is the model whose PC_1 value is less than PC value in experts repository. In different region land use model of sloping farmland should be determined according to natural and economic condition and nation's policy. For example, the finest land use model is returning farmland to forest while slope steepness is more than 25°.

2.3 Realization of management information system of sloping farmland in Three Gorges Reservoir region

Management information system of sloping farmland should have the function of chart display, statistics and analyses and map inquiry. The function module is as below(Figure 2):
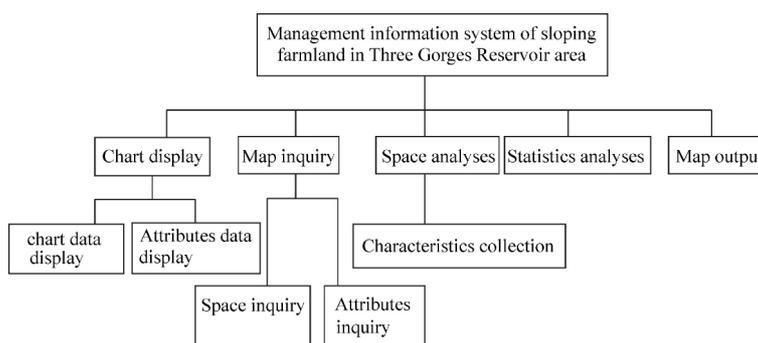
Fig.2 The function module of management information system

Because the system considers soil type map as base map, a definitive position of a sloping farmland would not be displayed while analyzing and evaluating a sloping farmland. But if a sloping farmland has a position supported by GPS system, a definitive position would be displayed on map.

2.4 Program design of management information system of sloping farmland in Three Gorges Reservoir area

By applying Map Objects provided by Institute of American Environment and System, this system designs program in Visual Basic language environment. Map Objects is a Active $\times$ which provides the function of drawing and GIS, it includes 35 Active $\times$ objects which may be programmed. The virtue of this system is to provide the function of map display and drawing while applied in other software.

Along with rapid development of spatial information science, digital picture treatment technology and computer hardware, 3S and 4D technology would be greatly applied in agricultural system. We may obtain a series of surface information of sloping farmland by applying RS, organize and manage farmland information through GIS, create simulated three-dimension gradient map of sloping farmland, finally these information may be provided to achieve a most rational land use model on sloping farmland.

References

[1] Yang Zisheng. A brief introduction of soil erosion and sustainable development research of sloping farmland in northeast mountainous region of Yunnan province. Journal of Mountain Science(Supplementary Issue), 1999(17), 1-5.

[2] Zhu Bo & Chen Shi. Utilization and protection of steep sloping farmland-a agro-forestry model. Journal of Mountain Science, 2000, **18**(1), 37-41.

[3] Shi Zhihua & Cai Chongfa. Application of GIS on comprehensive evaluation of soil fertility in Three Gorges Reservoir area, Journal of Soil Erosion and Soil and Water Conservation, 1999,**5**(1), 74-78.

[4] Wu Gang & Cai Qinghua, General expression of research contents on watershed ecology, Acta Ecologica Sinica, 1998,**18**(6):575-581.

[5] Small watershed comprehensive control and economic development in Zhejiang province. Bulletin of Soil and Water Conservation, 2000, **20**(3):50-54.

[6] T.A. Cocbrane，D.C. Flanagan. Assessing water erosion in small watersheds using WEPP with GIS and digital elevation models. Journal of Soil and Water Conservation，1999，**50**(2)：678-685.

[7] J.E. Gilley，B. Egbball. Narrow Grass Hedge Effects on Runoff and Soil Loss. Journal of Soil and Water Conservation，1999，**55**(2)：190-196.