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Soil erosion in China based on the 2000 national remote sensing survey

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This paper discussed the spatial distribution of soil erosion in China at the end of the 20th century based on the second national soil erosion survey. The result indicated soil erosion is still the prime environmental problem in China. Soil erosion mainly occurs in the western regions of China, and the slight erosion type, ion the whole, exerts the greatest impact on soil erosion pattern. The distribution of water erosion shows the impact of landforms: slight water erosion mainly in mountainous and hilly areas, and half of violent water erosion on the loess landforms. Farmland, forestland and grassland are the major land use types of slight hydraulic erosion distribution, while the serious hydraulic erosion and slight wind erosion mainly occur on grassland. Thus, the conservation of the grassland is the key to either hydraulic and wind erosion control. The huangmian soil (a major type of cultivated soil developed from loess mother material) is the one facing the most serious threat from soil erosion in Chinas soil resources. Further discussion on the soil erosion distribution still needs more research on the method and relevant data analysis.

XU Feng1,2, GUO Suoyan2, ZHANG Zengxiang1 (1. Institute of Remote Sensing Applications, CAS, Beijing 100101, China; 2. Monitoring Center of Soil and Water Conservation, Ministry of Water Soil erosion is generally regarded as the prime environmental problem of China, both to the government and the public. The Ministry of Water Resources (MWR) has evaluated area of soil erosion in China by geomorphologic survey and cartographic method in 1955. The MWR began the national soil erosion survey I supported by remote sensing using the mid-1980s Landsat MSS imageries around 1985. Global climate change and human activities have exerted some impacts on soil erosion in recent decade, while soil erosion is related with the regional environmental issues including water cycle, carbon cycle, and regional climate change by affecting land use/land cover change and other factors (An et al., 2000). In order to obtain new data of soil erosion in China, the MWR sponsored the national soil erosion survey II supported by remote sensing with the cooperation of the Chinese Academy of Sciences from 1999 to 2001. As the latest and most comprehensive data of soil erosion in China, the survey result was publicly proclaimed in January 2002. 1 Method 1.1 Background and introduction of the survey method Hu et al. (2001) pointed out that macroscopic data on soil erosion are usually obtained by upscaling from microscopic monitoring and statistics in US. And most of the European macroscopic research often obtains data from remote sensing images supported by GIS, considering soil erosion as the background of regional environmental problems is essential according to the national strategy and decision making of soil conservation (Brazier, 2001). Therefore, comprehensive studies on macroscopic spatial distribution and dynamic trend occupy the same important position as microscopic monitorng. Macroscopic research on soil erosoin in China has mainly depended on remote sensing data since the 1980s. For its distinct advantage of regional surface information obtaining (Tang, 2000), remote sensing will still be the major method of macrocopic soil erosion monitoring after the construction of the national networks of soil and water conservation monitoring in China is completed. The national soil erosion survey II established the national soil erosion database by GIS, using the mid-1990s Landsat TM5 images as the main data source, and integrating the enormous field surveys and calibration work. It is difficult to assess soil erosion module for there is not any suitable model for calculating regional soil erosion yet, thus some research work applied an integrated index to weigh soil erosion intensity by several relavant parameters affecting erosion. However, it is also difficult to limit the subjectinity on selection of those relavant parameters according to research on national scale. The soil erosion identification for the national soil erosion survey II was based on the national professional standard SL 190-96 Standards for Classification and Gradation of Soil Erosion, which guaranteed the comparability of this survey with historical data of

national and regional surveys. Based on the national standard, soil erosion was divided into three major types by th e main exogenous forces causing erosion: water erosion, wind erosion and frost-thaw erosion, and water or wind erosio n was divided into 6 gradations by certain factors affecting erosion. All the eroded area in a certain region means t he total area of water and wind erosion whose intensity is above the minimal erosion grade. 1.2 Technical route The m ain data source of the national soil erosion survey II was Landsat TM5 (wave band 2,3,4) pseudo color synthetic imag e on the scale of 1:100,000. The MWR organized field survey team for each province to set up image interpretation ind icates and to calibrate the image. Based on the TM image, digital 1:100,000 coverage of land use, DEM, and data of so il type, geology, sediment monitoring, the soil erosion coverage was set up by inter-human-computer image interpretat ion and integrated analysis supported by ARC/INFO 7.11, and established the major component of coverage of the nation al database of soil erosion after rigorous inspection. Digital national erosion map was merged by provincial coverag e. 1.3 Accuracy control standard of the survey More than 5% of figures of the database have been spot inspected. Acco rding to the image interpretation, the standard of accuracy exceeds 90%, and position deviation is 0.5 mm (2 pixels o n the screen). The minimal cartographical figure is (polygon) 6 pixels, and the minimal length for long figure is 4 p ixels. 2 Result of the survey and its primary analysis 2.1 Soil eroded area of each provincial region For the three p arts of China, it can be calculated that, soil eroded area of the eastern provincial regions (including Beijing, Tian jin, Shanghai, Jiangsu, Shandong, Fujian, Taiwan, Guangdong, and Hainan) occupied 8.13% of the total area of China, a nd the percentage of soil eroded area by the total soil eroded area in China is 2.74%. According to the central provi ncial regions (including Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan), the percentages are 24.28% and 14.64% respectively. And they are 70.78% and 82.61% for the western provincial regions res pectively (Table 1). And the percentage of soil eroded area by the total area of each part of China is 12.12%, 24.2 8%, and 15.89% respectively. 2.2 Soil erosion distribution for each type and grade According to the 5 erosion grades above the minimal grade (Table 2), the slight erosion (51.33% wind erosion +48.67%, annual erosion module ranges fro m 1,000 to 2,500 t/km2, the lower limits are different for different regions. MWR of the PRC, 1997) occupied 45.53% o f the total eroded area in China. And this percentage would be 78.20% pulsing the moderate erosion. The percentage o f slight water erosion by the total water erosion is 50.37%, and that of slight wind erosion by the total wind erosio n is 41.34%. Thus the slight erosion was the major grade in terms of asurvey rea, and it also could not be neglected that the continuously distributed large soil eroded area can affect regional environment significantly. The discussio n hereinafter will be mainly based on the continuously distributed large soil eroded area. (1) Slight soil erosion Th e major slight soil erosion continuous distributed area was the transitional zone between the first and second macros copic terrain steps, especially along the northeast-southwest line which is related with the distribution of mountain ous landforms affected by the longitude-direct geotectonic system. This northeast-southwest line is near to the demar cation of humid/arid region in China, also. The large continuously distributed wind eroded area-was mainly located i n the arid regions: the northern part of North China, the western part of Northeast China, and Northeast China. And w ind erosion is densely distributed in the boundary area of deserts and grasslands. Considering the dynamics of wind e rosion development, the potential danger exists in the large continuously distributed wind eroded area in areal expan sion and merging aggravating wind erosion driven by factors of climatic desiccation and irrational land use. Analysi s based on the 1:6,000,000 digital map of national soil erosion (synthetic compilation of the provincial maps, accura cy of eroded spot area 85.3%) indicated that the average area of slight water erosion was 96.24 km2 (9.43% of slight wind eroded area of 1,020.86 km2 and 29.52% of the total eroded) with the average area coefficient (area/perimeter) o f 1.01 (23.93% of light wind eroded area coefficient 4.22). That means the figures of slight water erosion were relet ively small with complicated shape and border even based on soil erosion map on a small scale. With a macroscopic vie w, it showed the impact on the level projection shape of water erosion distribution by mountainous landforms. The fig ures of slight water erosion were reletively large and simple. It also reflected the impact of landforms: reletively flat landforms, and little effect of landforms on the shape of distributing area. (2) Moderate and intense soil erosi on Moderate and intense soil erosion (annual soil erosion module ranges from 2,500 to 5,000 t/km2 and 5,000 to 8,000 t/km2 respectively) occupied 34.66% of the total soil eroded area. The continuous distribution of moderate and intens e water erosion with large area was similar to that of slight erosion which concentrated on the mountainous areas for med by the longitude-direct geotectonic system. Compared with slight wind erosion, there were more areas in the majo r deserts and sandy area of the distribution of moderate and intense wind erosion. (3) Serious soil erosion Serious s oil erosion (including very intense and severe grades, the annual erosion module ranges from 8,000 to 15,000 t/km2 an d 15,000 t/km2 respectively) occupied 19.81% of the total area of erosion. Reletively large area continuously distrib uting serious water erosion was located on the Loess Plateau, and hinterland of northwest deserts and sandy areas wer

e the main areas for large area continuously distributing serious wind erosion. These areas were suffering the most s erious soil erosion in China. 2.3 Characteristics of soil erosion distribution Certain disciplines of geographical ob ject distribution relates to the research scale. Similar with the multi-scale spatial characterization of land use/la nd cover (Chen et al., 2000), the discipline of macroscopic soil erosion distribution is closely related to the macro scopic research scale, and the spatial distribution characteristics of the factors affecting soil erosion. Based on t he national standard SL190-96, the slightly eroded areas refer to the area with relative good vegetative cover and lo w soil erosion module on gentle slope (5-8o). These areas were easily rehabilitated, and slight erosion is the first one with the most comprehensive distribution and area in all the erosion grades. And the serious erosion is the grad e with the most dangerous impact on regional environment although its percentage of area was limited. Therefore, the discussion thereinafter mainly focuses on the slight and serious soil erosion. Gridding the vector maps is essential for the multi-thematic analysis. The minimal figure area on digital map of the national soil erosion was 4 mm2, or 1 2 ×12 km2 on the site. For basically remaining the figure information, the gridding unit for the digital map of the national soil erosion was selected as 5 km2 (less than 1/5 of the minimum figure, and was theoretically presumed tha t the smallest figure would not be lost after gridding). After converting the projection system and scale, a prelimin ary analysis on the soil erosion and mainly related factors by overlaying and relating digital coverages (derived fro m the 1:4,000,000 digital atlas of Chinese resources and environment by the State Key Lab of Resources and Environmen tal Information System, CAS, 1998) was possible. (1) Landforms (2) Land use (3) Soil 3 Conclusions The national soil erosion survey II reflected the integral situation of soil erosion in China at the end of the 20th century. The tota l area of soil erosion was 3.56 million km2, that means 37.42% of the investigated land was suffering from soil erosi on and more than the percent of land was suffering from the hazard by soil erosion. Soil erosion is still the top env ironmental problem that continuously affects China. Analysis by gridding supported by GIS (5 ×5 km2) preserving the main information of vector maps showed the major macroscopic characteristics of the soil erosion distribution. (1) Th e western region of China (occupies 70.78% of the total land area of China) including 12 provinces (autonomous region s, municipality) was the major soil erosion distributed region (occupies 82.61% of the total soil erosded area of Chi na). The slight erosion occupied 45.53% of the total erosded area in China being most extensive in distribution. And this percentage would be 78.20% pulsing the moderate erosion. The percentage of slight water erosion to total water e rosion is 50.37%, and that of slight wind erosion to total wind erosion is 41.34%. And the slight erosion was the maj or grade for the spatial pattern of soil erosion in the case of both erosion control and the percentage of area. The percentage of moderate erosion of the total eroded area was 22.67% as the second grade in area, which is a difficult task for control . (2) The distribution of water erosion distinctly reflected the impact of landforms: slight water e rosion was mainly distributed in mountainous and hilly areas, and nearly half of the serious water erosion was distri buted in loess landforms area; while the percentage of wind erosion distribution in mountainous and hilly areas was s mall. The major land use types of slight water erosion distribution were farmland, forestland, and grassland. Nearly half of the hilly/mountainous grassland suffered from serious water erosion, and nearly half of the range grassland s uffered from slight wind erosion while meadow/steppe soil types were mainly located in the major distributed areas o f slight wind erosion. Therefore, the conservation and rehabilitation of grassland is an important issue both for win d and water erosion. According to soil resource under serious erosion threat, the loessal soil should be considered a t first. (3) This paper just analyzed erosion data only in combination with data of land use, soil, and landforms fro m a weath of data. A more reasonable analysis on the characteristics of soil erosion distribution in China need more data support: the soil erosion distribution should be reviewed and studied on a larger (continental or subcontinenta l) scale, including the background of land use/land cover, soil distribution, spatial pattern of climate, and their l ong term change in central and eastern Asia. Further research is absolutely essential: assessment on regional soil er osion module, comparison of the accuracy changing with gridding by different units, particular analysis on relevant d ata of vegetation cover (especially close surface cover) and regional hydrological/sediment monitoring for the suppor t of national strategy of soil conservation.

关键词： soil erosion; spatial distribution; remote sensing survey; China

