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Characteristics and control of soil erosion in Hubei Province, China

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Abstract Surface soil erosion in Hubei Province, China is statistically calculated and characteristics such as climate-, plant-, and soil-conditions, erosion severity and distribution, and damages and causes are analyzed. An annual soil thickness of 1.66 cm, an amount of 319 billion kg, is eroded from mountains, hills, and farmlands causing unfavorable effects on the environment and eco-social systems. Also, measurements and planning for erosion control are discussed. It may be summarized that monitoring research and erosion control needs to be expanded.

INTRODUCTION

Hubei Province is located in central China, with an area of 185 900 km^2 and a population of 51.4 million (Fig. 1). The climate is typical of the sub-tropical monsoonal zone. Annual rainfall is 1166 mm and annual runoff is 528 mm. Nearly 74 percent of the land surface consists of loamy soils, and only 20.3 percent is covered by forests. Moreover, the landscape is mainly mountains and hills, 70.6 percent of the total area. Mountains higher than 500 m above sea level comprise 56 percent of the area.

Several factors – steep hillslopes, poor vegetation cover, flood flows, torrential streamflow, and dense population – contribute to severe soil erosion. surface soil is eroded by various forces such as rainfall, wind, and human activities, and transported along river valleys onto the plains and lakes, causing substantial damages to the agricultural economy and environment. Therefore, the characteristics and controls of soil erosion are analyzed in this paper, based on hydrological data gathered from field monitoring networks, and on remote-sensing data.

SEVERITY OF EROSION

Erosion occurs in an area of 61 300 km^2, or about one-third of the total land area. Annual sediment yield is 319 billion kilograms; of which 180 billion kilograms come from the highly eroded regions of 19.600 km^2 in area. Compared with an ares of 50 120 km^2 in the early 1950's it has increased by 11,180 km^2, or 22.3 percent, in spite of erosion control practices on 27 842 km^2. The soils are primarily eroded and transported by surface runoff or by runoff-related landslides and debris flows.

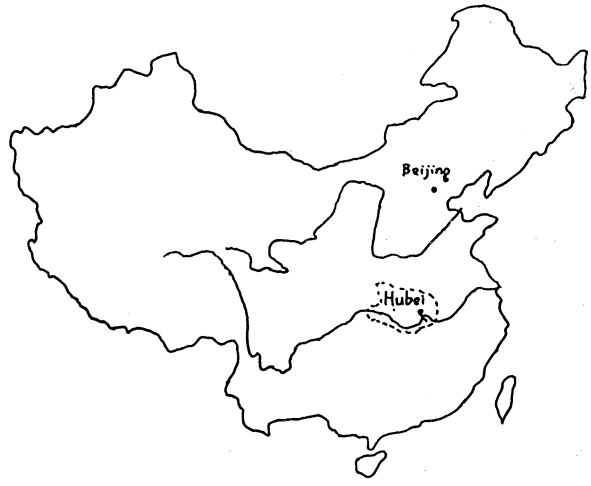

Fig. 1 The location of Hubei Province in China.

Total erosion in the area may be divided into five categories according to erosion severity, as shown in Table 1. According to four criteria, for example, surface soil type, underlying rock type, erosion force, and resistance to erosion to surface material. Fluvial erosion of the land surface in Hubei Province may be spatially mapped as follows (see Fig. 2):

(A) Soft, weathered rocks and yellow-colored loamy soils are exposed in the northwest mountains. Because vegetation cover has been severely depleted or destroyed, and cultivation of steep mountain slopes, erosion is generally more than 3.0×10^6 kg/km^2. It is the most severely eroded region of Hubei Province.

(B) Northeast and southeast mountains are made up of granitic rocks and yellow or red loam soils, with a weathering depth of 20 to 30 m. Caused by biological, physical, and chemical weathering, the soil and rock matrix contain large amounts of original minerals, but organic material is less than one percent. Therefore, the top layer is loose, coarse, and lacking clay particles. It is also a severely eroded region.

(C) In the northern hills the soil is predominately Quaternary clay. In the upper layer, clay-size particles (<0.1 mm in diameter) comprise more than 50 percent of the material, and organic material comprises less than one percent. Therefore,

Table 1 Severity division.

Category (x10^{6}kg/km^2 · a)	Erosion index (km^2)	Area (%)	Area percentage (%)
Light	0.5-2.5	7 965	13.0
Moderate	2.5-5.0	33 738	55.1
Severe	5.0-8.0	9 202	15.0
Extremely severe	8.0-13.5	7 461	12.2
Most severe	>13.5	2 903	4.7

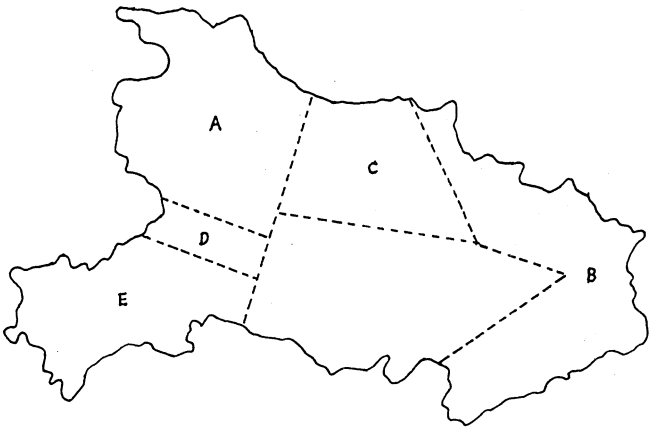

Fig. 2 Spatial division of soil erosion.

the soils have low hydraulic conductivity and a high runoff coefficient, being easily eroded.

(D) The Three-Gorge valleys are underlain by a violet granite bedrock matrix, and yellow or violet loamy soils exposed at the surface. The region is noted for its severe erosion. It is located at the upper reaches of Gezhouba dam and the Three-Gorge reservoir. The granite bedrock is very permeable and nutrients are drained to depth. The topsoil has little resistance to erosion, and the steep valley is sparsely vegetated. On some sites as many as 8000 t of soil per km^2 may be removed in one year.

(E) The southwest mountains are covered by loam and limestone bedrock, with a good vegetation cover. The limestone is readily eroded and topsoil is consequently very shallow. Where vegetation cannot be sustained, soil erosion occurs and bedrock is exposed. Furthermore, there are many eroded gullies, and gravity collapse (piping) is common in the region.

EROSION DAMAGE

Soil erosion destroys both land and water resources. It also changes in soil properties, nutrient content, and plant communities. Major damages are described in the following discussion.

Nutrient loss

On average, a thickness of 1.66 cm of topsoil is removed each year. Of this soil, there are 1.7 billion kg of nitrogen, 3.2 billion kg of phosphorus, and 40.9 billion kg of potassium. Overland flow transports fine soil and nutrients from upland areas, deposits coarse sands and gravels, and as a result farmlands degrade progressively from year to year. On the other hand, soils coming from mountainous areas may cover farmlands and completely inundate crops.

River or lake deposition

Erosion has increased sediment concentrations in the flows of more than 20 rivers by 20 to 40 percent since 1973. The Yangtze River and its tributaries in Hubei Province receive 2.57 billion kg of sediment annually, creating a substantial threat to river-dike safety and social development. Efficiency and substantial threat to river-dike safety and social development. Efficiency and storage capacity of reservoirs and lakes are also challenged. One of the major hydro-power plants in Hubei Province, Danjiangkou reservoir, has a capacity of 16 billion m^3. The annual sediment load of 0.12 billion m^3 raised the bed level by 5.5 m in the period 1967-1976. As for Honghu Lake, the largest reservoir in Hubei Province, its area decreased rapidly from 687 km^2 in the 1960's to the present 353 km^2, and the flood regulation capacity was reduced by 4 billion m^3.

Environmental deterioration

All types of vegetation cover – trees, grasses, and agricultural crops do not grow well in areas of severe erosion. Ecosystems in these regions become fragile and mountain torrents, debris flows, and landslides present severe natural hazards.

CAUSES OF EROSION

The main erosion process in the region, overland flow, is controlled by natural and artificial factors. Key factors are discussed in the following paragraphs.

Storm flow

In the mountains and hilly topography, annual rainfall usually exceeds 1000 mm, and 50 to 70 percent of the rainfall occurs in the four-month period May to August when the rainfall pattern of sustained rain is accompanied by wind. These heavy rainstorms are a primary force in erosion.

Steep topography

Although eastern, northern, and western territories are high mountain area, the south-central area is a vast plain. Between the steep mountains and the vast plain there are distributed many mounds and grasslands. Steep slopes in these areas are easily eroded.

Sparse vegetation

There are 20 677 km^2 of barren hills in the region that have not been forested yet, and the average cover-ration is as low as 20.3 percent. Furthermore, a large population

makes the forested stand per person to be only 800 m^2, a value of 8.7 percent. On the other hand, these forests are not uniformly distributed, and northern regions have more than half the forest lands. This poor vegetation cover condition promotes soil erosion.

Poor land use

Many farmers still use a primitive pattern of cultivation. They reclaim land and grow crops on steep terrains. They cultivate soils perpendicular to the hillslope contours in place of along contours. Hydraulic, transportational, industrial, mining, and urban development also have caused severe soil erosion.

PLAN FOR EROSION CONTROL

Water and soil conservation have been studied and tried for 40 years, and much experience and progress has been made. Measurements include:

(a) creating or repairing 1.16 million pools;
(b) construction of 6200 reservoirs on 1100 rivers;
(c) afforestation of trees on 20 861 km^2 of land;
(d) terracing steep fields on 3567 km^2 into flat fields;
(e) putting 7667 km^2 of farmlands into order;
(f) reforming 5687 km^2 of low-yield farms; and
(g) conservation on small watersheds totalling 2284 km^2.

After all these activities, 56 000 km^2 of land have been controlled. Twenty-six billion m^3 of runoff can be stored and managed, and a 27 842 km^2 area has been primarily controlled.

Now local governments and scientists are starting on a plan for soil and water conservation (1991-2000), which includes three aspects:

(a) to afforest with protective trees and timber trees on barren hills in an area of 14 674 km^2;
(b) to bring slope cultivation under control, which is the main source of erosion. About 1667 km^2 of steep farmland will be terraced into flat fields; and
(c) to construct small flood-control dams in the region of severe erosion. After the above plan is completed, a new area of 23 000 km^2 will be protected.

Finally, it might be concluded that both protection and control should be given much attention and intensive measurements be made for severely eroded fields. Ground cover might be used as the alternative for regions of low erosion.