

Analysis of the Effect of the Human Activity on the Changes of the Sediment in the Jinghe Watershed

—Concurrently Discussing the Fathering Stratagem of the Jinghe Watershed

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Abstract: In recent years, increase of soil and water loss caused by human activity is increasing with the year, among which opening up wasteland is the main reason for the increase. In 1990s, the annual increase of flood caused by human activity was $1,510 \times 10^4 \text{ m}^3$, with the annual increase of sediment $1,465 \times 10^4 \text{ t}$, which had an increased of 26.4% and 40.2% compared to that in 1980s respectively, and an increase of 85.3% and 69% compared to that in 1970s respectively. It's an urgent mission to hold back the increase of soil and water loss. Only the ecological construction is carried out synchronously with the West Development Project, can it be possible to realize the economical and social sustainable development in the Jinghe Watershed.

Keywords: human activity, water and sediment changes, jinghe watershed, fathering stratagem

1 Introduction of the watershed

Jinghe River origins from the Laolong deep pond, which located on the east foot of Liupan Mountain in Ningxia Municipality of the Hui Nationality, runs across three provinces of Ningxia, Gansu and Shaanxi, and confluges into the Weihe River at Chenjiatan in Shaanxi. Jinghe River located on the central part of the Loess Plateau, its whole trunk stream is 455.1 km, and the total acreage of the watershed is 45,421 km², among which water erosion region is 33,220 km², accounting for 73.1% of the watershed. Topographical types in the watershed can be divided into 5 types: loessial highland section, ravine section, mountain section of earth material, loessial forest highland section, and mesa-butte sections, among which loessial highland section and ravine section were most eroded areas, and occupy 41.3% and 39.7% of the watershed respectively. The annual erosion modulus on loessial highland section is 10,000t/(km² · a), 4,000 t/(km² · a) on ravine section. The areas of the other 3 types of mountain section of earth material, loessial forest highland section, and mesa-butte sections were 3,295 km², 2,937 km² and 2,361 km² respectively, accounting for 7.3%, 6.5%, and 5.2% of the watershed respectively.

2 Calculation of the increase of soil and water loss caused by human activity

According to the investigation, the main types of the increase of soil and water loss caused by human activity in Jinhe Watershed were opening up wasteland, mining, constructing road, and digging medical herbs. The opening up wasteland in Jinghe watershed can be divided into 2 types: one is opening up wasteland on steep slope, that is opening on non-woodland; the other is opening by destroying woodland.

There were 4 reasons for opening up wasteland: ① the sharp conflict between population and land resource caused by too high increasing ratio of the population; ② blindly increasing the areas of the field without quality; ③ the structure of local productions was not reasonable, and resulted too much

dependence on planting; ④ land-using for non-production, especially for capital construction, increased, and mostly occupied plain field.

The effects of opening up wasteland on steep slope on the acceleration of soil erosion were the following: reducing the surface soil anti-erodibility by cutting down the vegetation; inducing the decrease of soil fertility by changing soil structure; and accelerating soil erosion by lessening the infiltration ratio.

Opening up wasteland by cutting down woodland is an important reason for the changes of water and sediment production in Jinghe watershed. The results of the interception of forest vegetation to the flood from Xifeng Soil and Water Conservation Experiment Station of Huanghe Committee indicated that averagely, forest vegetation could impound 70% of the flood with the highest of 90%, 60% flood peak runoff, and 99%~100% of sediment production. Compared to the forested watershed (mainly caused by human activity), the average sediment contents of the flood and the max of it from non-forested watershed are 440 and 34 times respectively to that from forested watershed.

2.1 Calculation of sediment increase caused by opening up wasteland on steep slope

According to the land investigation of the counties in 1990 and 1996, areas of steep slope were calculated by assuming that field on slope over 25° is steep slope. Until 1996, the opening areas on steep slope were $105,700\text{hm}^2$ after checking. Then the increase of water and sediment by opening on the steep slope could be reached by timing the opening areas and increase of water and sediment modulus.

The increase of flood and sediment modulus was determined by comparing the runoff and sediment from runoff plots of farming and natural wasteland. In this study, the increase of sediment modulus by opening wasteland on steep slope is $6,570\text{ t/km}^2$.

Moreover, opening wasteland by cutting down woodland in Jinghe watershed also was a serious problem. According to statistics, there was $311,200\text{hm}^2$ natural forest in 1969, but in 1989, there was only $217,100\text{hm}^2$ of it, which resulted $100 \times 10^4\text{t}$ increase of sediment each year. In 1970s, annual increase of flood was $500 \times 10^4\text{m}^3$, $600 \times 10^4\text{m}^3$ in 1980s. What's more, the annual increase of flood in 1990s was $700 \times 10^4\text{m}^3$, $170 \times 10^4\text{t}$ of sediment.

2.2 Calculation of sediment increase caused by constructing road and mining

2.2.1 Calculation of sediment increase by constructing road

According to the investigation of the counties in 1990 and 1996, the length and areas of county road until 1996 was $36,375\text{km}$ and $29,100\text{hm}^2$ respectively, and the highways was $8,180\text{km}$ and $9,730\text{hm}^2$ respectively.

The method for calculation the spoil from constructing road was the following: First we have to calculate the length of the road by its area with the same breadth of 12m and 8m to the highway and county road respectively. Then we'll calculate the spoil volume according to bulk of earthwork per kilometer, to which the bulk of earthwork per kilometer of highway was $35,000\text{m}^3$, $10,000\text{m}^3$ of county road. Based on the assumption that 30% of the spoil was scoured into the gully, the runoff ratio on highways was 38%, 25% on county roads. Among the total spoil, those in 1960s accounted for 15%, 20% in 1970s, 25% in 1980s, and 40% in 1990s, whose contribution to the annual flood was determined by its coefficient.

Moreover, according to the investigation, the total spoil from the Bao—Zhong railway running across upper branches of Jinghe watershed, which was constructed in Eighth Five Years Plan, was $2,750 \times 10^4\text{t}$, among which $1,170 \times 10^4\text{t}$ was washed off.

2.2.2 Calculation of spoil by mining and welling

According to the investigation, from 1990 to 1996, over 700 wells were drilled on Changqing Oil Field in the tributary river—Huanjiang Watershed of the Jinghe River. Assuming there were 750 wells, and spoil from each well is $20,000\text{m}^3$, runoff ratio 15%, bulk density of the spoil 1.35t/m^3 , the total spoil from well is $750 \times 20,000 \times 15\% \times 1.35 = 303.75 \times 10^4\text{t}$, and their contributions to the annual flood were determined by its coefficient.

2.2.3 Calculation of increase of flood by constructing road and mining

Based on the statistical analysis of the data from runoff plots in Tianshui, Xifeng and Suide soil and water experiment station, the difference of annual runoff ratio between road and wasteland was determined as annual increase modulus of water. According to the observation on the runoff plots in the field, average annual runoff modulus of road was $61,180\text{m}^3/\text{km}^2$, and compared to the wasteland, the increase of annual runoff modulus was $20,800\text{m}^3/\text{km}^2$. Based on this, the increase of flood can be reached according to the areas of roads, counties, and mining areas.

2.3 Calculation of spoil caused by digging medical herbs

As the northwest part of Jinghe watershed is rich in liquorice and other medical herbs, the soil and water loss caused by digging medical herbs was also a serious problem. According to the investigation in Qingyang of Gansu Province in 1989, from 1950 to 1987, the destroyed areas by digging medical herbs was $11,465\text{hm}^2$, with $3,062 \times 10^4\text{t}$ spoil. If the runoff ratio was 25%, the annual soil loss was $20.68 \times 10^4\text{t}$, in 1990s, this kind abuse of destroying ecological environment and vegetation went from worse to worse. According to investigation, from 1988 to 1996, the spoil on the upper part of Jinghe watershed by digging medical herbs was high as $1500 \times 10^4\text{t}$, and its annual loss ratio was $50 \times 10^4\text{t}$ or so.

2.4 Calculation the increase of sediment from the destroyed engineering by flood

The main engineering types on Jinghe watershed were reservoir, check dams for building farmlands, and channels. According to the investigation of water conservancy section in Qingyang and Pingliang, from 1950 to 1989, the destroyed hydraulic works by flood in the two areas were over 64,000, with the annual soil loss $24.5 \times 10^4\text{t}$, and $980 \times 10^4\text{t}$ as a whole. Moreover, in 1990s, there were three great floods happened in 1992, 1994 and 1996 successively, especially the flood in July 1996 resulted more serious damaging to the hydraulic project along Jing River. It was estimated that the sediment loss due to flood was over $35 \times 10^4\text{t}$.

The increase of flood caused by human activity was shown in table 1, and the increase of sediment caused by human activity was shown in Table 2.

It was clear that in 1970s, the annual increase of flood and sediment were $814 \times 10^4\text{m}^3$ and $867 \times 10^4\text{t}$ respectively; in 1980s, the annual increase of flood and sediment were $1,193 \times 10^4\text{m}^3$ and $1,045 \times 10^4\text{t}$ respectively; and in 1990s, the annual increase of flood and sediment were $1,508 \times 10^4\text{m}^3$ and $1,465 \times 10^4\text{t}$ respectively. Compared to 1970s and 1980s, the runoff caused by human activity increased 85.3% and 26.4% respectively, while the sediment caused by human activity increased 69.0% and 40.2% respectively. Currently, it's an urgent mission to stop the increase of the soil and water loss caused by human activity. Only the ecological construction is carried out synchronously with the West Development Project, can it be possible to realize the economical and social sustainable development in the Jinghe Watershed.

Table 1 The increase of flood caused by human activity

Years	Opening up wasteland on steep slope	Opening up wasteland by cutting down woodland	County road	Highway	Railway	Mining	Digging medical material	Destroy the hydraulic works by flood	Total
1956—1969	-473.15	0.00	-61.40	-62.10	0.00	-4.22	-2.00	-24.50	-627.37
1970—1979	-557.09	-100.00	-88.38	-87.35	0.00	-6.08	-4.00	-24.50	-867.40
1980—1989	-639.69	-130.00	-110.48	-109.18	0.00	-7.59	-24.00	-24.50	-1045.44
1990—1996	-722.37	-170.00	-154.02	-149.56	-167.14	-17.36	-50.00	-35.00	-1465.45
1970—1996	-630.53	-129.26	-113.58	-111.56	-43.33	-9.56	-23.33	-27.22	-1088.39
1956—1996	-576.79	-85.12	-95.76	-94.67	-28.54	-7.74	-16.05	-26.29	-930.97

Table 2 The increase of sediment caused by human activity

Years	Destroying forest and opening up wasteland	County roads	Highway	Mining areas	Total
1956—1969	0.00	-141.22	-49.20	-22.05	-212.47
1970—1979	-500.00	-211.85	-70.83	-31.74	-814.42
1980—1989	-600.00	-364.81	-188.54	-39.68	-1193.03
1990—1996	-700.00	-451.95	-301.30	-54.41	-1507.66
1970—1996	-588.89	-330.75	-174.18	-40.56	-1134.38
1956—1996	-387.80	-266.03	-131.50	-34.24	-819.58

3 Discussing the fathering stratagem of the jinghe watershed

Currently, the project for soil and water conservation and ecological construction on the coarser sandy areas along Yellow River has been started. Jinghe River located on the middle reaches of Yellow River, and its coarser sandy sections was 12,392km², among which the tributary river—Huanjiang—was the famous source for the coarser sand ($d \geq 0.05\text{mm}$). Jinghe River functioned as a connecting link between the east and the west, and the author thought the fathering stratagem of the Jinghe watershed should be the following: sticking to prevention and cure simultaneously, fathering slope and gully simultaneously, paying attention to vegetation construction and conservation, intensifying the surveillance, trying to control the increase of the soil and water loss areas; at the same time with the slope fathering, strengthening the channel fathering, especially the construction of the mainstay of the dam system along the channel to realize the target of reducing water erosion, conserve soil and water, ameliorating local ecological environment.

Currently, soil and water conservation and ecological construction on the Loess Plateau has been received too much recognition and attention from the central government. In 1997, president Jiang Zemin called on to construct a beautiful landscape of mountains and rivers in Northwest; on June and August, 1999, president Jiang and the Prime Minister Zhurongji visit Yellow River personally, and gave important directions. Now, ecological construction has been one of the important parts in the West Development Project, and the basis and point to cut-in to realize the target of the West Development Project. In the soil and water conservation works in Jinghe River, it is important to carry out the important directions of fathering and developing Yellow River from President Jiang, fulfill the policy put foreword by Prime Minister Zhu, and firmly stop new opening wasteland by destroying woodland and grassland. As the topographical conditions in Jinghe Watershed were complex, it should be stick to adjust measures to local conditions and comprehensive fathering, especially to the question of reusing farmland for forest and grass. Forestry and grass measures were the fundamental methods for the construction and maintenance of the favorable ecological environment. So it is important to solve the problem of planting right trees on the right sites, intensifying management, and firmly stop human induced destroy. Only the ecological construction is carried out synchronously with the West Development Project, can it be possible to realize the economical and social sustainable development in the Jinghe Watershed.

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