Analysis of the Benefits of Soil and Water Conservation for Comprehensive Harness in Qinggangba Small Watershed

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Abstract: Based on Qinggangba watershed comprehensive harness, the research, according to the investigations, experiments, and observed data obtained by Nanzhao soil and water conservation station before and after controlling it, useing the method of watershed hydrologic factor comparison and of surface runoff flood hydrograph comparison, has drawn the conclusion that the capacity for retaining the surface runoff has increased on an average by about 6 percent annually, and the capacity for diversion of sediment has reduced by 60 percent. It is also shown that there is an obvious effect of cutting and lagging fllod on the simulated rainfall sub-flood process.

1 Background

Nowadays, the calculation of benefits of Soil and Water Conservation after comprehensive control over soil erosion is the controversial subject in Soil and Water Conservation and water conservancy academy. In general there are two opinions. One is that method of Soil and Water Conservation is from a dot to a surface and it is more systemic, but the disadvantage is that the quota is not accurate; the basic data are not elaborate and reliable; the result of calculation often is not conformity to the reality. So it is required that the coefficients need to be adjusted .The other thinks that the hydrologic method is coincide with reality, but it is confined by the incomplete series of records of small river and the complicating effective factors of big rivers. However, it is a trend that the benefits of soil and water conservation for comprehensive control will be taken into consideration by using hydrologic method in some regions in future.

2 Watershed situations

Qinggangba small watershed, lied in Qinggangba village of Nanzhao county in Henan province, belongs to the third-class tributary of the Tangbai river system of the Yangtse River. It consists of two cross minor grooves like the form of "Y". The total area is 19.8 km^2. Its topography features a low hill, the gradients of which averages 27. The length of main watercourse is 9 km, which gradient is 33%, the gully density of watershed is 2.4km/km^2—2.5 km/km^2 and the average year-rainfall is 989mm, of which the rainfall from June to September accounts for 68%. Before 1982, the average depth of watershed runoff is 415.3mm, the runoff coefficient is 0.42, and geological rock is granite. The main earth types are brown earth and yellow brown earth, with a pH value of 6.0—7.5. Vegetation consists of evergreen conifer forest and deciduous broad-leaved forest which are mixed alternately. The tree species almost are *Pinus massoniana Lamb.*,*Quercus acutissima Carruth.*,*Quercus mongolica Fisch*. ect. Now the land is used as forest land (44.4%), sericutural land (41.4%), agricultural land (6.1%)and range land (2.9 %). The whole watershed has 20 village groups, 68 hamlets,465 households, and 1,874 people. The average basic agricultural land is 0.065hm^2, individual possessing food supplies are 429kg. Its natural conditions and social economy are of typical representative in the southwest of Henan province.

3 Soil erosion and control situations

Owing to many reasons in the soil erosion, the Qinggangba watershed was rather serious in the past. A great deal of vegetation was destroyed. The A and B-layers of slope soil were denuded completely, and the C-layer was exposed mostly. The mother material formed from the granite weathering is quite loose

and weak against erosion. According to the investigation made by Nanzhao soil and conservation station in 1983, eroded soil above light-degree was 10.78 km^2 in watershed, among the eroded, light-degree was 5.02 km^2, medium-degree was 5.36 km^2. The way of erosion was surface erosion, granule surface erosion, and gully erosion. The mixed erosion occurs on the part of the plot now and then.

In 1981, after the Nanzhao soil and water conservation scientific research station was restored, the small watershed being regarded as a unit, comprehensive control was implemented, over mountains, water, farm fields, forests, and roads as a whole planned. In 1988, the plan was checked and confirmed by the experts in the field of water conservancy and soil control in Henan province. By the end of this period, 16.4km^2 of land with soil and water loss had been harnessed, accounting for 83 % in total area. The main measures: 56 pond dams with 600,000 m^3 of total capacity;340 dams for building farmland, which has the area of 27.3hm^2; 23,989 m check dams of 390,000 m^3 amount of holding sediment; 2 small Ⅱ reservoirs of 270,000 m^3 storage capacity; 11 segments where the curving watercourse was straightened, repairing 8,500 m embankment, digging 129,000 m ditch for draining flood, repairing 7,500m irrigation canal; protecting forest 446.7 hm^2, afforested hills which covered 349.6 hm^2, improving sericultural slope 630 hm^2; rebuilding terrace 13.9 hm^2, changing watercourse and making land 19.7 hm^2, expanding irrigated land 500 hm^2. With the effects of engineering and vegetation's measures, the whole watershed average erosion index could be reduced below slight-degree.

4 Analysis of benefits of soil and water conservation

4.1 Analysis of changing of rainfall, runoff and transported sediment

Heping valley, is the main tributary of Qinggangba watershed with an area of 12.62 km^2. There are 290 reservoirs, ponds, dams and 16,729 check dams. Its vegetation cover reaches 84%. The Soil and Water Conservation facilities were all in readiness and the level of comprehensive erosion control was high. Nanzhao soil and water conservation station established the general control of survey transect in the exit. They also set up three basic raindrops in watershed and calculated the rainfall according to the weight.

Table 1 Heping valley added-up yearly rainfall, runoff, sediment transport statistical table

Duration	Items / Year	Year Precipitation(mm)		Amount of Runoff(mm)		Amount of Sediment Transport(t)	
		Year in which year (P)	Add-up (ΣP)	Year in which year (R)	Add-up (ΣR)	Year in which year (W)	Add-up (ΣW)
First duration	1984	960.5		450.1		141	
	1985	972.9	1,933.4	408.5	858.6	205	346
	1986	884.6	2,818.0	306.8	1,165.4	133	479
	1987	1,034.6	3,852.6	389.9	1,555.3	59.0	538
	1988	979.2	4,831.8	427.7	1,983	117	655
Sub-total			4,831.8		1,983		655
Second duration	1989	1,045.4		447.9		59.5	
	1990	1,249.8	2,295.2	625.6	1,073.5	161	220.5
	1991	1,040.5	3,335.7	395.0	1,468.5	50.9	271.4
	1992	743.1	4,078.8	116.2	1,584.7	22.5	293.9
	1993	895.2	4,974	228.6	1,813.3	3.0	296.9
	1994	794.3	5,768.3	170.9	1,984.2	7.2	304.1
	1995	1,089.9	6,858.2	495.6	2,479.8	57.0	361.1
	1996	1,327.9	8,186.1	665.9	3,145.7	52.0	413.1
Sub-total			8,186.1		3,145.7		413.1
total			13,017.9		5,128.7		1,068.1

Through the statistics of rainfall, runoff, transported sediment materials from 1984 to 1996 in Heping valley, within 13 years, the total precipitation in the watershed is 13,017.9mm and average rainfall 1,001.4 mm per year. Its runoff depth is 5,128.7mm and average 394.5mm per year .Its runoff coefficient is 0.394. Its suspended load amount of sediment transport is 1068.1 ton and average 82.2 tons per year. But according to the time limits that we finished control work in the end of 1987 and accompanied checking and confirming, the benefits were derived in 1988. We divided these 13-year materials into two durations (Table 1). In the first duration, average rainfall was 966.36mm,which is less 56.9mm than that in the second duration (showed that first was drier than the second). The average runoff depth of the first duration was beyond 3.4mm,average runoff coefficient was higher 0.026 than that of the second duration. This indicated that between 1984 and 1988,the rainfall was less than the average, while runoff was more than the average. The benefits from facilities of soil and water conservation were not exerted. Still the rainfall drained to the ground cover in a great deal of surface runoff, meanwhile, the transported sediment differs obviously between them. When the two durations are compared, the average capacity of holding surface runoff and sediment holding concentration of the second duration increased by more 6.44% and 60.61% respectively than that of the first duration (Table 2).

Table 2 Soil and water conservation benefits calculation table of the Heping valley

Duration	Yearly average precipitation (mm)	Yearly average runoff (mm)	Yearly Average Runoff Coefficient	Difference of runoff coefficient in two durations	Amount of holded Run-off (%)	Amount of transported sediment (t)	Difference of transported sediment in two durations	Amount of increaseing percent of holded Sediment (%)
first duration	966.4	396.6	0.410	0.026	6.44	131.0	79.4	60.61
second duration	1 023.3	393.2	0.384			51.6		

4.2 Analysis of similar sub-rainfall, runoff, sediment change

4.2.1 Choosing similar sub-rainfall

Through selecting and analyzing the totaling 134 runoff generating rain in 13 years, the researchers thought that the rainfall process on 14,8,1986 is quite similar to that on 28,8,1994. The benefits of Soil and Water Conservation can be used as analysis of similar sub-rainfall. The main foundations are:

- The basic same antecedent rainfall influence. On 5,8 before it rained on 14,8,1986, there was a rainfall of 30.1mm precipitation and the 6.25mm/hour average rainfall intensity. On 17,8 before it rained on 28,8,1994, there also was a rainfall process of the 37.6mm precipitation and the 5.9mm/hour average rainfall intensity.
- The basic identical totaling precipitation. In 1986,the total amount of rainfall was 135.9mm and it lasted 25.83 hours. In 1994, the total precipitation was 132.3mm and it lasted 11.5 hours.
- The basic identical season of precipitation. According to the utilization law of flood control for Henan water conservancy engineering of flood period, in the major flood period (from the last ten days of July to the first ten days of August), we mainly drained and vacate the storage capacity. After flood period, we began to hold water gradually. Two rainfalls took place "the last ten days of July and the first ten days of August" later. As far as water conservancy engineering influence on the formation and convergency is concerned, they were identical.

However, it is rather difficult to choose two completely identical process of rainfall type. Similarly, there are differences between two types as follows:

- The different average rainfall intensity. In 1986 average rainfall intensity reached 5.26mm/hour while in 1994 it did 115.0mm/hour. But from analyzing the benefits of Soil and Water Conservation, even though they had difference, the latter was not favorable the former.

- The different process of rainfall type. From Fig.1 and Fig. 2 of two rainfall type processes, the process of 1986 was the double-peak rainfall while the process of 1994 was single-peak rainfall. It was quite complicate that the change of this rainfall type reflected the formation and convergency change and cutting-off flood, namely positive effect and negative effect.

4.2.2 Analyzing the runoff and sediment change

According to calculation table of Heping valley distribution similar formation of benefits of soil and water conservation (Table 3) and rainfall, discharge of flaw hydrograph (Fig. 1, 2), we could drew a conclusion that carrying out comprehensive control for soil conservation altered some factors that rainfall formed formation and convergency. As regard sub-flood, it changed obviously as follows:

Table 3 Heping valley similar formation of benefits of soil and water conservation table

ComPa-Rison Flood	Rainfall Situation			Discharge of flow (m^3/s)		Total precipitation (10^4m^3)	Total runoff (10^4m^3)	runoff coefficient	Amount of holded sediment in runoff (kg/m^3)		Transported sediment (T)
	Preci-pitation (mm)	Duration (h:m)	average rainfall intensity (mm/h)	maximum	average				maximum	average	
860814	135.9	25:50	5.26	10.1	7.43	130.74	112.4	0.860	2.5	0.862	969
940828	132.3	11:30	11.5	7.15	3. 62	127.27	39.10	0.307	0.344	0.101	39.5

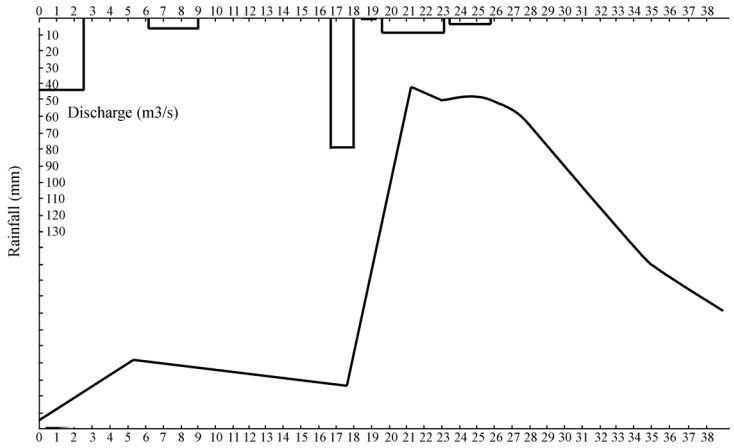

Fig.1 Rainfall & discharge curves in Hepinggou branches from 20.14. Aug.to 10.16. Aug.1986

- Flood rising time was stagnant. In 1986, the sub-flood rised with the beginning of rainfall process as surface runoff also rised at the same time, while in 1994 the sub-flood happened at 23 o'clock on 28,8 due to the holding of Soil and Water Conservation engineering and tree and grass vegetation, the runoff rose at 2 o'clock on 29,8.The lull between rainfall and runoff was nearly three hours. At first the runoff hydrograph rose gradually. After added-up rainfall and rainfall intensity reached the certain degree, it began to change suddenly. The Soil and Water Conservation engineering had a role in the effect of holding back flood.
- The effect of reducing flood peak was evident. The discharge of maximum flood flow in 1986 was 10.1 m^3/s and flood runoff coefficient was 0.800 $m^3/(s \cdot km^2)$. They increased respectively more 2.95 m^3/s and more 0.233 $m^3/(s \cdot km^2)$ than those in 1994.This indicated that formation and convergency of Heping valley changed the rising and dropping rapidly into the ascending and descending gradually for the measures of Soil and Water Conservation.
- It was obvious effect to turn the holding surface runoff into underground runoff. The totaling precipitation of two rainfalls was hardly different. But the sub-flood of the total amount of the surface runoff differed by nearly 700,000 m^3. Compared the year of 1986 with the year of

1994,the benefits of holding surface runoff increased by 64.3% and the flood average discharge of flow reduced by 51.3 %. The holding and storing water effect of Soil and Water Conservation measures was quite evident.

- The effect of soil conservation was prominent. With the dropping of discharge of flow for flood peak and total amount of runoff and the reducing of the velocity of flow for the holding water of Soil and Water Conservation measures, amount of runoff sediment transport also reduced. As a result, the maximum sediment content and average sediment content dropped respectively by 86.2 percent and by 88.2%, the amount of sediment transport reduced by 95.9%. So the holding sediment effect of Soil and Water Conservation measures has proved to be prominent.

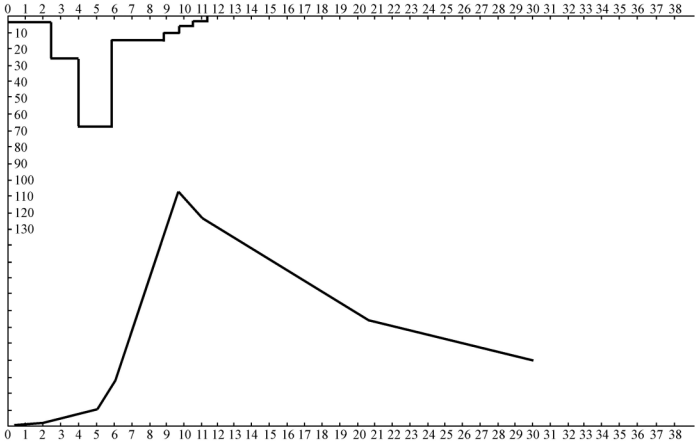

Fig.2 Rainfall & discharge curves in Hepinggou branch from 2,29, Aug.10,30,Aug.1994

5 Conclusion

- Using the method of watershed hydrologic factor comparison and flood hydrograph comparison analysis, the researchers analyzed the characteristic value of formation and convergency for different durations, years and sub-flood in Heping valley. We drew a conclusion that after exerting Soil and Water Conservation measures, the capacity of holding surface runoff improved by 6.44%—64.3 % and the amount of transported sediment reduced by 60.61%—95.9% following the different durations. But according to the analysis of the stage of precipitation of 13 years, the total capacity of holding surface runoff increased about 6 % and the amount of sediment transport reduced about 60 % in Heping valley.
- If taking the average rainfall of 989mm for many years in Qinggangba watershed as the standard, we found that through comprehensive harness of Soil and Water Conservation, the amount of the holding water of total watershed net increased 1,175,000 m^3. Among them, except the small part of them evaporated and then returned to the atmosphere after the cutting off by tree crowns, the large part of them was held in the valley, water conservancy engineering, and wither matters on ground and soil, thus increasing the total amount of water circulation of watershed, strengthening the capacity of combating draught and catastrophe every year. If taking average erosion coefficient of 1,800 tone as standard, the watershed would reduce the amount of soil erosion of 21,384 tons, and it was equal to avoiding soil erosion of 1.46 mm.

6 Discussion

Compared with the large watershed, the relation between rainfall and runoff in small watershed was more complicated and variable. Besides rainfall type, rainfall intensity, antecedent rainfall amount, it was effectted by the crop interception, field moisture capacity, the utility of ponds in the watershed and so on. It was very difficult for us to analyze and study and it was confined to the sources of materials, if we choose the completely identical rainfall process and consider all other factors except for the rainfall.

Therefore, there is the great difference in the capacity of holding runoff. But when analyzing the yearly duration, we could minimize effect of the occasional factors. So, the 6% holding runoff effect and 60 % soil conservation effect was consistent with the real change of Qinggangba watershed.

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