ESTIMATION OF WATER CONSERVATION CAPACITY OF WATERSHED FOREST ECOSYSTEM FROM THE PERSPECTIVE OF VILLAGES: A CASE STUDY OF THE DAOTIAN RIVER BASIN IN CHINA

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Abstract. The water conservation role played by forest ecosystems encompasses intricate processes involving the redistribution of rainfall through the layers of vegetation, litter, and soil. Leveraging a comprehensive approach to assess the water storage capacity, we utilized secondary forest resource survey data to estimate canopy interception precipitation, litter retention capacity, and soil water storage within the Daotianhe River Basin in China's Guizhou province. Adopting a village-centric perspective, we proceeded to analyze the basin-wide water conservation capacity and its spatial variations across the forest ecosystem. The findings indicate the following: ① The total amount of water conserved by forests in the Daotian River basin is approximately 1907.68×10^3 m^3, with a water conservation capacity of 23.32×10^3 m^3/km^2. ② Administrative villages exhibiting heightened water conservation capacities are primarily situated in proximity to the main stream of the Daotian River Basin, specifically Beishan Village (7.2%), Hongfeng Village (7.1%), Liujia Village (7.11%), Baichun Village (13.29%), and Huashi Village (9.65%). ③ In terms of spatial distribution, the forests in the study area possess a higher water conservation capacity in the southwest and a relatively lower capacity in the northeast. Notably, the majority of the water conservation function is attributable to the forests in the southwest, contributing to 58.62% of the overall conservation efforts.
Keywords: *watershed forest ecosystem, forest water conservation, comprehensive water storage capacity method, Daotian River Basin, China*

Introduction

Water conservation function of a forest ecosystem is an important part of its ecological function (Uniyal et al., 2019). Forest affects hydrological process of watershed, promotes rainfall redistribution, mitigates surface runoff, and increases soil runoff and underground runoff through interception, retention and accumulation of rainfall by canopy, litter and soil (Long et al., 2015). Therefore, its water conservation function is essentially a complex process of rainfall redistribution by vegetation layer, litter layer and soil layer (Bhatta, 2015). The main functions are increasing available water resources, regulating runoff and sediment, and purifying water quality' should be used instead. Since the middle of the 20th century, a large number of scholars have studied the hydrological process and formation mechanism of forest water conservation function and evaluated it for different regions, scales or types of forest ecosystems (Kaura et al., 2019; Liu et al., 2021). Due to the diversity of China's landform, climate conditions and forest types, the water conservation function of China's forests has great regional differentiation, showing a

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gradually increasing trend from north to South and from west to East (Vogl et al., 2016; Guidotti et al., 2020).

From the perspective of rural scale, it is of great significance to study the water conservation of watershed forest ecosystem for water resources security, irrigation and agricultural development, flood prevention, ecological protection and restoration, and rural tourism development. Residents and farmland in rural areas are often highly dependent on water conservation of watershed forests. The study on water conservation of forest ecosystem in the watershed is helpful to understand the supply and change trend of water resources, and provides a scientific basis for the protection of water resources in rural areas. Also, agriculture is an important industry in rural areas, and the water conservation capacity of watershed forest ecosystem is directly related to the irrigation demand of farmland. By studying the water conservation of forest ecosystem in the basin, we can formulate reasonable farmland water resources management strategies and promote the sustainable development of agriculture. Third, flood prevention and control in rural areas need to understand the water conservation capacity of watershed forests, so as to formulate scientific flood control and water resources regulation measures and reduce the risk of flood disasters. Fourth, the watershed forest ecosystem is very important to maintain biodiversity, protect soil and maintain ecological balance. Research on water conservation of watershed forest ecosystem can provide key information, help design and implement reasonable ecological protection and restoration plan, and improve the quality of ecological environment in rural areas. Finally, the attraction of the beautiful landscape and unique ecological characteristics of the watershed forests to rural tourism cannot be ignored. By studying the water conservation capacity of watershed forest ecosystem, we can provide guidance for rural tourism planning, protect and rationally use watershed forest resources, and promote the sustainable development of rural tourism.

The karst area in Southwest China is a very important fragile ecological function area in China (Wang and Long, 2009). Since the 20th century, the forest coverage in this area has declined sharply, soil erosion and rocky desertification have intensified, soil quality has deteriorated and water holding capacity has declined, and ecological functions have deteriorated seriously (Lalika et al., 2015). Water is one of the most active and important factors in karst areas, and also one of the main limiting factors for vegetation restoration, and it is also an important guarantee for the livelihood and development of rural residents (Wang et al., 2019). Therefore, it is of great ecological significance to study the water conservation function and its temporal and spatial distribution pattern of forest ecosystem in rural settlements in karst areas. At the same time, the forest ecosystem in the Daotian River Basin is an important tributary on the right bank of the upper reaches of the Yangtze River, and an important water source for production, living and ecological water in the Yangtze River Delta and "reducing salt and replenishing fresh water" in the lower reaches of the Pearl River. However, due to its special karst landform type, the basin also faces the problem of water shortage, and the engineering water shortage is serious, which makes the water conservation function of forest ecosystem in the basin particularly important. Therefore, the scientific assessment of water conservation capacity of forest ecosystem in the Daotian River Basin from the village scale has scientific guiding significance for its protection and management.

This study selected the forest ecosystem in the Daotianhe River Basin in Bijie City, a typical karst area, as the research object. Based on the class II survey data of forest resources, according to the comprehensive water storage capacity method, the water conservation function and spatial distribution pattern of the forest ecosystem in the

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Daotianhe River Basin were analyzed, which can reflect the differences of water conservation function in rural areas in the study area, and provide a scientific reference for the rational management and management of rural forests, In order to maximize the function of water conservation of forest ecosystem, promote soil and water conservation in karst areas, and prevent the aggravation of land rocky desertification. By studying the current situation and function of water conservation of watershed forest ecosystem at the village scale, its contribution to water resources and influencing factors were analyzed. Scientific assessment and monitoring can provide important basis and data support for water resources management. At the same time, the study can also promote the integration and coordination of watershed management, and strengthen the cooperation and communication between different stakeholders. In a word, through in-depth study and full use of the water conservation capacity of the watershed forest ecosystem, we can realize the sustainable use of water resources, protect the ecological environment, promote economic prosperity, and create a better life for people.

Materials and methods

Study area

The Daotian River Basin in Qixingguan District of Bijie City is located 2 km northwest of Qixingguan District, between 105°7′40″ -105°16′4″ east longitude and 27°16′1″ - 27°21′50″ north latitude (*Fig. 1*). The Daotian River Basin is a typical representative of river basins on the plateau in southwestern China. The basin area is 87.36 km^2, 16.76 km long from east to west and 9.12 km wide from south to north. As a water conservation and ecological restoration area in the upper reaches of Chishui River, the Daotian River Basin mainly establishes and improves the ecological environment system of blue sky, green land, clean water and clear gas, so as to ensure that the water quality in the main stream reaches the class II standard, ensure the safety of water for the production of Maotai flavor liquor in the middle and lower reaches of Chishui River, and build an ecological safety barrier.

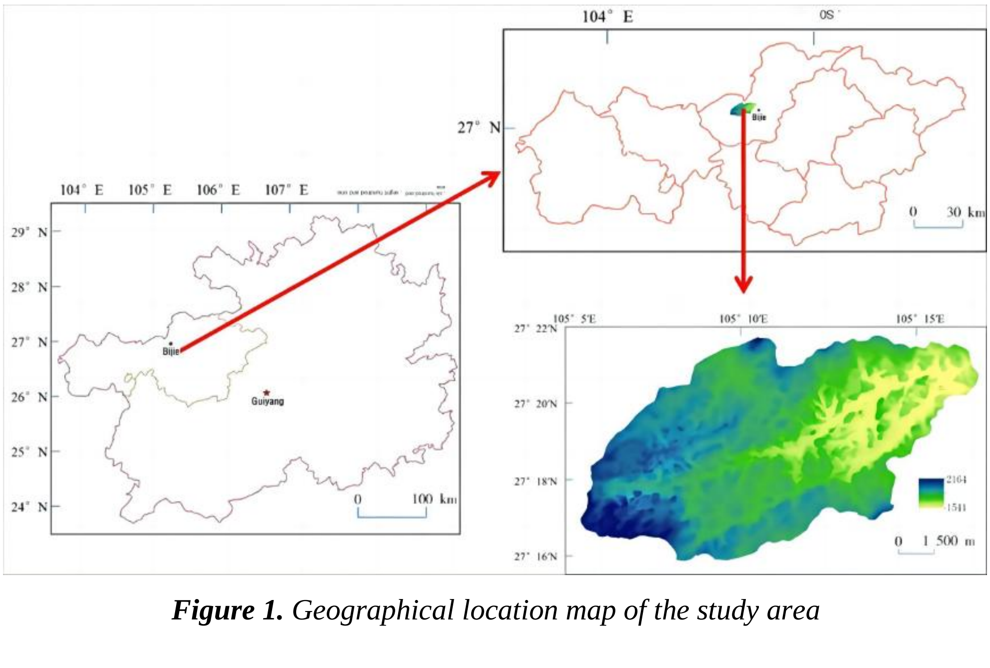

Figure 1. *Geographical location map of the study area*

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Data sources and research methods

The land use status data adopts the ALOS (2022, 10m resolution) digital image of Japan's earth observation satellite. Based on the 1:50000 topographic map, the land use/cover information was extracted by human-computer interactive interpretation.

At the same time, on the basis of consulting a large number of literature, the relevant parameters for estimating water conservation of various forest types in the yellow soil hilly region of southern China, including canopy closure, maximum water holding capacity of litter layer and soil non capillary porosity, were collected. As shown in *Table 1.*

Table 1. *Relevant parameters for estimation of water conservation capacity of different forest types*

Forest type	Canopy interception (%)	Maximum water holding capacity of litter (t/hm^2)	Soil non capillary porosity (%)
Evergreen coniferous forest	15.7	19	9.9
Broad-leaved forest	17.8	23.3	13.8
Mixed forest	13.8	22.3	11.2
Shrubbery	--	15.6	9.1

Note: references to Wen and Liu (1995), Zhao and Zhou (2004), Pan (2006)

Research methods

We use the integrated water storage capacity method to estimate and analyze the forest canopy interception (Ci), litter holding capacity (Li) and soil layer water storage (Si) in the forest ecosystem in the study area to assess different regional scales. Water conservation capacity and its spatial and temporal distribution pattern of forest ecosystems. According to the comprehensive water storage capacity method, the total water conservation capacity of forest ecosystems (Wi) is:

$$Wi = Ci + Li + Si \quad \text{(Eq.1)}$$

where, Wi is the water storage capacity of the forest ecosystem. Ci is the interception precipitation of the canopy. Li is the water holding capacity of the litter layer. Si is the water storage capacity of the soil.

In the article soil thickness data is derived from the second survey data of the second forest resources in Guizhou Province. In the 2012 Qixingguan District Tianbao Project Artificial Forestation Small Class Survey, the thickness of the soil layer is about 40-65 cm. Combined with the slope map generated by the DEM map, we roughly calculate the slope range of different forest land types in each village. Finally, based on the above slope estimation, we got the thickness of the soil layer of various forest types.

Forest canopy interception (Ci):

$$Ci = \sum_{i=1}^{n} ai . R . Ai \quad \text{(Eq.2)}$$

In the formula: a represents the canopy interception rate (%). R represents the precipitation (mm). A represents the area (hm^2). i represents the vegetation type. The

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single maximum precipitation in the paper is monitored by the Bijie Meteorological Station from 1970 to 2022.

Litter layer (Li):

$$Li = \sum_{i=1}^{n} \mathrm{Bi.A}\, i \quad \text{(Eq.3)}$$

In the formula: B represents the maximum water holding capacity of the litter layer (t / hm^2). A represents the area (hm^2). i represents the vegetation type.

Soil layer water storage capacity (Si):

$$Si = \sum_{i=1}^{n} Yi.D.Ai \quad \text{(Eq.4)}$$

In the formula: Y represents soil non-capillary porosity (%). D represents soil depth. A represents area. i represents vegetation type.

Results and analysis

Estimation of rainfall intercepted by forest canopy

The canopy intercepts part of the precipitation, prolongs the time for precipitation to reach the surface, is conducive to water infiltration, delays the formation of surface runoff, and reduces the kinetic energy of raindrops when it rains, reducing the possibility of soil and water loss to a certain extent. The amount of rainfall intercepted by forest canopy is not only related to rainfall, rainfall intensity, rainfall duration and other factors, but also related to vegetation type, stand structure, canopy density and other characteristics (Sanz-Benito et al., 2022). The canopy interception capacity of different forest ecosystems varies. The average canopy interception of various forest ecosystems in China varies from 134.0 mm to 843.4 mm, and the average interception rate varies from 11.4% to 36.5% (Huang et al., 2016). Based on the vegetation coverage map interpreted from the remote sensing image of the Daotian River Basin in 2022, this paper uses ArcGIS software to realize the superposition of the village boundary map and the vegetation map of the basin, and extract the relevant forest land area of each village in the basin. According to *Eq.1* and *Table 1*, the canopy interception precipitation of each village is calculated, as shown in *Table 2*.

The total rainfall intercepted by forest canopy in administrative villages of Daotianhe River Basin was 226.77 × 10^3m^3. The average water conservation capacity of canopy interception per unit area was 2.77 × $10^3m^3/km^2$, of which 9 villages are higher than the average, accounting for 34.6% of the total number of villages, and the highest is 10.62% in chating village × $10^3m^3/km^2$, with the minimum value of 0.09 for Yaguan village, except for five empty villages × 10^3 m^3/km^2, with a difference of 123.8 times. The rainfall intercepted by forest canopy deviated from the water conservation amount intercepted by forest canopy per unit area.

The spatial difference of canopy interception precipitation showed a decreasing trend from southwest to northeast. The peak value appears in Bailong village at the southwest end of the basin, and decreases from Bailong village to Tianshengqiao village through Tangguan village.

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Table 2. *Estimation results of forest canopy interception precipitation in administrative villages of Daotianhe River Basin (10^3 m^3)*

Village	forest canopy water content (10^3m^3)	Water content per unit ($10^3m^3/km^2$)	Village	forest canopy water content (10^3m^3)	Water content per unit ($10^3m^3/km^2$)
Limin	1.2	1.04	Yinguantun	9.33	5.15
Beishan	18.77	4.21	Yongfeng	-	-
Houqing	12.34	3.91	Huashi	21.9	2.74
Yaguan	0.1	0.09	Lingfeng	8.2	2.82
Tangguan	9.05	2.41	Xiniu	0.23	0.56
Dapo	12.5	2.19	Baiguo	-	-
Dawan	0.057	0.31	Bailong	35.34	4.82
Tianxing	-	-	Hongfeng	14.2	2.19
Tianshengqiao	10.42	2.65	Cuixi	3.48	10.50
Xiaohe	-	-	Chating	17.4	10.62
Ganyan	17.03	4.56	Weijia	5.73	1.73
Gangou	-	-	Longguan	9.49	2.73
Liujia	18.12	4.01	Longhan	1.88	0.27

Estimation of litter water capacity

The structure of litter layer is loose, with good water permeability and water holding capacity, which can reduce the flow kinetic energy, reduce surface runoff, and play the role of water and soil conservation and water conservation (Somogyi, 2016; Cunha et al., 2016). Research shows that when there is a litter layer of 0.5 cm, the runoff velocity is only 10%-20% of that without litter (Schroeder-Georgi et al., 2015). Its water holding capacity is closely related to the standing crop of litter, and the two are in a significant linear positive correlation, and the amount of water absorbed can reach 2-3 times its own dry weight (Randin et al., 2020). According to *Eq.3* and *Table 1*, the maximum water holding capacity of the litter layer in each village is calculated in this paper, and the results are shown in *Table 3*.

Table 3. *Estimation results of litter holding capacity of administrative villages in Daotian River Basin (10^3m^3)*

Village	Total amount of water held by litter (10^3m^3)	Unit litter holding capacity ($10^3m^3/km^2$)	Village	Total amount of water held by litter (10^3m^3)	Unit litter holding capacity ($10^3m^3/km^2$)
Limin	1.13	0.98	Yinguantun	2.44	1.35
Beishan	5.54	1.24	Yongfeng	0.22	0.79
Houqing	3.99	1.26	Huashi	9	1.13
Yaguan	0.96	0.82	Lingfeng	3.3	1.14
Tangguan	4.3	1.15	Xiniu	0.4	0.98
Dapo	6.4	1.12	Baiguo	4.63	0.80
Dawan	0.16	0.88	Bailong	9.55	1.30
Tianxing	0.27	0.81	Hongfeng	7.27	1.12
Tianshengqiao	4.58	1.16	Cuixi	0.55	1.66
Xiaohe	0.15	0.78	Chating	2.47	1.51
Ganyan	4.71	1.26	Weijia	3.56	1.08
Gangou	0.63	0.79	Longguan	4.08	1.17
Liujia	5.57	1.23	Longhan	6.03	0.86

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The total water holding capacity of litter layer in administrative villages of Daotianhe River Basin was 91.89 × 10^3 m^3. The average water conservation capacity of litter per unit area was 1.09 × $10^3 m^3$, of which 15 villages are higher than the average, accounting for 56.69% of the total number of villages, and the highest is Cuixi Village 1.66 × 10^3 m^3, with the lowest value of 0.78 in Xiaohe Village × 10^3 m^3, with a difference of 2.13 times.

The spatial difference trend of litter holding capacity and canopy interception precipitation was the same, which showed a decreasing trend from southwest to northeast. However, the spatial difference of water conservation capacity per unit area of litter was not significant.

Estimation of soil water storage

The soil layer of forest land is the most important place for water storage in forest ecosystem. The soil water storage capacity mainly depends on soil texture, pore status and soil depth. Soil water storage capacity is mainly reflected in the water holding capacity of soil non capillary pores. The research shows that the non-capillary pore water storage of 0-60 cm soil layer changes from 36.42 to 142.2 mm, and the maximum water storage is 286.3-486.6 mm (Juerges, 2018). According to *Table 1* and *Eq.4*, the water holding capacity of excavated soil is calculated, and the results are shown in *Table 4*.

Table 4. *Estimation results of soil water capacity of administrative villages in Daotian River Basin (10^3m^3)*

Village	Soil water holding capacity (10^3m^3)	Water content per unit ($10^3m^3/km^2$)	Village	Soil water holding capacity (10^3m^3)	Water content per unit ($10^3m^3/km^2$)
Limin	19.58	16.90	Yinguantun	42.76	23.62
Beishan	94.47	21.19	Yongfeng	3.91	14.00
Houqing	69.91	22.14	Huashi	152.9	19.14
Yaguan	16.83	14.43	Lingfeng	56.07	19.31
Tangguan	75	20.01	Xiniu	6.6	16.10
Dapo	112	19.66	Baiguo	81	14.01
Dawan	2.77	15.31	Bailong	165	22.50
Tianxing	4.65	14.00	Hongfeng	127.7	19.71
Tianshengqiao	80.5	20.44	Cuixi	9.63	29.06
Xiaohe	2.7	14.00	Chating	38.87	23.72
Ganyan	80.13	21.46	Weijia	62.45	18.88
Gangou	11.15	14.01	Longguan	71.8	20.62
Liujia	95.14	21.07	Longhan	105.5	15.13

The total soil water holding capacity of administrative villages in Daotian river basin is 1589.02 × 10^3 m^3. The average water conservation capacity per unit area of soil is 18.86 × 10^3m^3, of which 16 villages are higher than the average, accounting for 61.54% of the total number of villages, and the highest is Cuixi village, 29.06 × 10^3 m^3, the lowest value is Tianxing village 14 × 10^3 m^3, with a difference of 2.08 times. There is a spatial deviation between soil water capacity and average water conservation per unit area of soil.

The spatial difference trend of soil water holding capacity and canopy interception precipitation is the same, which shows a decreasing trend from southwest to northeast.

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Estimation of water conservation in administrative villages

According to the above calculated data, the water conservation amount of each administrative village in the basin is calculated according to the relevant parameters in *Table 1* and *Eq.1*, as shown in *Table 5*.

Table 5. *Estimation results of water conservation capacity of forest ecosystem in administrative villages of Daotian River Basin (m^3)*

Village	Forest canopy water content ($10^3 m^3$)	Litter holding capacity ($10^3 m^3$)	Soil water holding capacity ($10^3 m^3$)	Water conservation ($10^3 m^3$)	Per unit water conservation (m^3 / hm^2)
Limin	1.2	1.13	19.58	21.91	18.92
Beishan	18.77	5.54	94.47	118.78	26.65
Houqing	12.34	3.99	69.91	86.24	27.31
Yaguan	0.13	0.96	16.83	17.89	15.34
Tangguan	9.05	4.28	75.2	88.35	23.57
Dapo	12.52	6.4	112.47	130.9	22.97
Dawan	0.057	0.16	2.77	2.987	16.51
Tianxing	0	0.27	4.65	4.92	14.81
Tianshengqiao	10.42	4.58	80.54	95.5	24.24
Xiaohe	0	0.15	2.7	2.85	14.78
Ganyan	17.03	4.71	80.13	101.87	27.28
Gangou	0	0.63	11.15	11.78	14.80
Liujia	18.12	5.57	95.14	118.83	26.31
Yinguantun	9.33	2.44	42.76	54.53	30.12
Yongfeng	0	0.22	3.91	4.13	14.79
Huashi	21.91	9	152.94	183.8	23.01
Lingfeng	8.19	3.3	56.07	67.57	23.27
Xiniu	0.23	0.38	6.57	7.23	17.63
Baiguo	0	4.63	80.98	85.63	14.81
Bailong	35.34	9.55	164.89	209.89	28.62
Hongfeng	14.22	7.27	127.74	149.17	23.03
Cuixi	3.48	0.55	9.63	13.66	41.23
Chating	17.44	2.47	38.87	58.74	35.84
Weijia	5.73	3.56	62.45	71.74	21.68
Longguan	9.49	4.08	71.8	85.37	24.52
Longhan	1.88	6.03	105.5	113.41	16.26

The comprehensive water conservation capacity of the forest ecosystem in the administrative villages of the Daotian river basin is the sum of the water storage capacity of the canopy, litter and soil layers (Tardy et al., 2015). According to the calculation, the total water conservation amount of the basin is 1907.68×10^3 m^3, of which the canopy interception is 226.77×10^3 m^3, accounting for 11.89% of the total; The water holding capacity of litter layer was 91.89×10^3 m^3, accounting for 4.81% of the total. Soil water storage is 1589.02×10^3 m^3, accounting for 83.30% of the total, which is the main body of forest water conservation.

The administrative villages with higher contribution rates of water conservation are Beishan Village (7.2%), Hongfeng Village (7.1%), Liujia Village (7.11%), Baichun Village (13.29%) and Huashi Village (9.65%), while Dawan Village (0.09%), Yongfeng

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Village (0.11%), Xiaohe Village (0.07%) and Xiniu Village (0.23%) have lower contribution rates. Administrative villages with high water conservation are mainly distributed near the main stream of the Daotian River Basin, which is due to the high forest coverage. The ArcGIS classification system is randomly divided into five levels, as shown in *Fig. 2*. It can be seen that the comprehensive water conservation capacity of the forest ecosystem in the inverted Tianhe river basin is high in the east and low in the west, which is consistent with the decreasing trend of altitude from southwest to northeast.

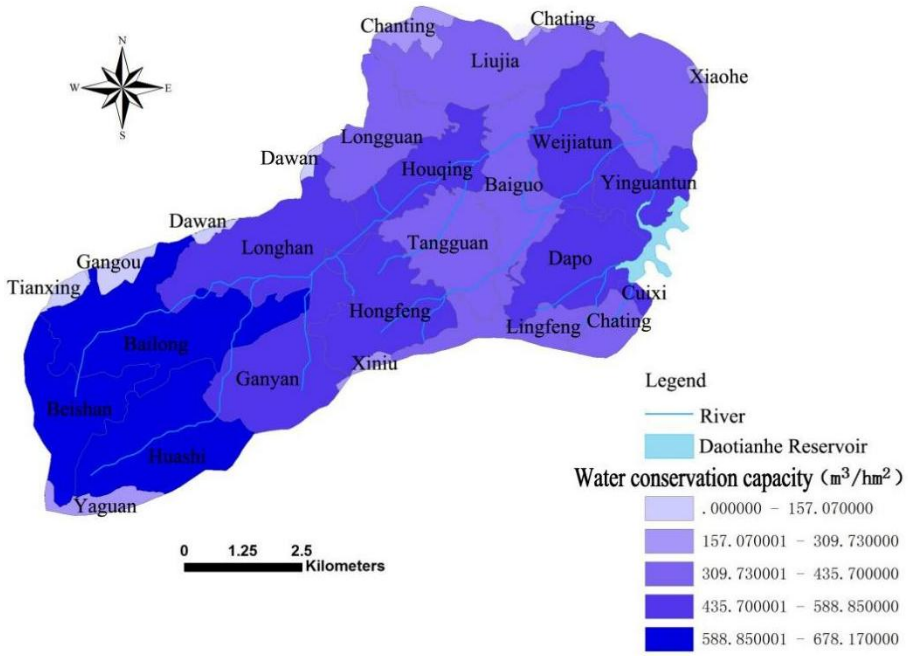

***Figure 2.** spatial distribution of water conservation capacity in Daotian River Basin*

Discussion

In this study, the comprehensive water storage capacity method was selected to evaluate the water conservation function of the forest ecosystem in the Daotian River Basin in Qixingguan District, Bijie City, Guizhou Province. The comprehensive consideration of canopy interception, litter water retention and soil water storage was helpful to compare and analyze the water retention and lowering functions of different action layers. Due to the special karst landform in this area, the rock exposure rate is high, the soil is shallow, the soil cover is discontinuous, and the average soil layer is thin (Meng et al., 2020). The proportion of soil water storage in the total water conservation is lower than that of other regional research results (Caputo et al., 2016). At the same time, due to the barren soil, poor water storage capacity and low biomass in karst areas, the amount of litter is lower than that of vegetation in non karst areas (Mutoko and Hein, 2015). The water capacity of litter layer in the study area only accounts for 4.81% of the total, and the retention capacity is poor. However, the litter layer can reduce the flow kinetic energy, delay the surface runoff, inhibit the surface evaporation, improve the soil properties, prevent soil erosion, and reduce water and soil loss. In addition to the role of water and soil conservation and water conservation, the existence of litter layer can also effectively inhibit soil water evaporation, thereby improving the water conservation capacity of soil

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layer, so its hydrological role must not be ignored (Wu et al., 2012; Caputo and Butler, 2017).

Because the comprehensive water storage capacity method requires a large number of measured data, at present, the measured data in and around the study area can only be collected through published literature, so the accuracy of the evaluation results is not enough. At the same time, in this estimation, the maximum interception of single maximum precipitation from 1970 to 2020 is adopted, and the influence of forest evapotranspiration consumption is ignored. Therefore, the conclusion only reflects the maximum water storage capacity of the forest ecosystem in the study area in theory, and does not represent the water storage capacity of the forest in the actual state (Kaura et al., 2019).

Conclusion

Utilizing data from forest resources surveys and literature sources, this study delved into estimating the maximum water conservation capacity of the forest ecosystem within the Daotianhe River Basin in Qixingguan District of Bijie City. Applying the comprehensive water storage capacity approach, the investigation further examined and compared the disparities in water conservation functions among different types of forest ecosystems and Village Units, taking into account their temporal and spatial distribution patterns. The findings uncovered the following key insights:

(1) In 2022, the study area exhibited a remarkable total water conservation capacity of 1907.68×10^3 m^3, translating to a water conservation capacity of 23.32×10^3 m^3/km^2. Notably, the canopy interception, litter holding capacity, and soil water storage contributed 11.89%, 4.81%, and 83.30% of the total, respectively.

(2) The administrative villages closest to the main stream of the Daotian River Basin showcased higher water conservation capacities primarily due to their extensive forest coverage. Noteworthy contributors to water conservation included Beishan Village (7.2%), Hongfeng Village (7.1%), Liujia Village (7.11%), Baichun Village (13.29%), and Huashi Village (9.65%). Conversely, Dawan Village (0.09%), Yongfeng Village (0.11%), Xiaohe Village (0.07%), and Xiniu Village (0.23%) exhibited comparably lower rates of contribution.

(3) Spatially, a distinct trend emerged, with the water conservation capacity of the forests in the study area peaking in the southwest and decreasing gradually towards the northeast. The primary contributor to water conservation was the forests in the southwest, accounting for an impressive contribution rate of 58.62%.

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REFERENCES

[1] Bhatta, L. D. (2015): Ecosystem services and livelihoods in a changing climate: understanding local adaptations in the upper Koshi, Nepal. – International Journal of Biodiversity Science Ecosystem Services & Management 11(2): 145-155.

[2] Caputo, J. B., Beier, C. M., Groffman, P. M., Burns, D. A., Beall, F. D., Hazlett, P. W., Yorks, T. E. (2016): Effects of harvesting forest biomass on water and climate regulation

services: a synthesis of long-term ecosystem experiments in eastern north America. – Ecosystems 19: 271-283.
[3] Caputo, J., Butler, B. (2017): Ecosystem Service Supply and Capacity on U.S. Family Forestlands. – Forests 8(10): 395.
[4] Cunha, D. G. F., Sabogal-Paz, L. P., Dodds, W. K. (2016): Land use influence on raw surface water quality and treatment costs for drinking supply in So Paulo state (Brazil). – Ecological Engineering 94: 516-524.
[5] Guidotti, V., de Barros-Ferraz, S. F. Pinto, L. F. G., Sparovek, G., Taniwaki, R. H., Garcia, L. G., Brancalion, P. H. S. (2020): Changes in brazil's forest code can erode the potential of riparian buffers to supply watershed services. – Land Use Policy 94: 104511.
[6] Huang, L., Cao, W., Gong, G. L., Zhao, G. S. (2016): Spatial and temporal variations in ecosystems in the three northern regions of China, 2000-2010. – Acta Ecologica Sinica 36(1): 107-117.
[7] Juerges, N. B. S. (2018): A tool to analyse instruments for soil governance: the reel-framework. – Journal of Environmental Policy & Planning 20(5): 617-631.
[8] Kaura, M., Arias, M. E., Benjamin, J. A., Oeurng, C., Cochrane, T. A. (2019): Benefits of forest conservation on riverine sediment and hydropower in the Tonle Sap Basin, Cambodia. – Ecosystem Services 39: 101003.
[9] Lalika, M. C. S., Meire, P., Ngaga, Y. M. (2015): Exploring watershed conservation and water governance along Pangani River basin, Tanzania. – Land Use Policy 48: 351-361.
[10] Liu, Z., Li, K., Xiong, K., Li, Y., Wang, J., Sun, J. (2021): Effects of *Zanthoxylum bungeanum* planting on soil hydraulic properties and soil moisture in a karst area. – Agricultural Water Management 257: 107125.
[11] Long, R. P., Bailey, S. W., Horsley, S. B., Hall, T. J., Swistock, B. R., Dewalle, D. R. (2015): Long-term effects of forest liming on soil, soil leachate, and foliage chemistry in northern Pennsylvania. – Soil Science Society of America Journal 79(4): 1223-1236.
[12] Meng, Y., Liu, X., Ding, C., Xu, B., Zhu, L. (2020): Analysis of ecological resilience to evaluate the inherent maintenance capacity of a forest ecosystem using a dense Landsat time series. – Ecological Informatics 57: 101064.
[13] Mutoko, M. C., Hein, S. (2015): Tropical forest conservation versus conversion trade-offs: insights from analysis of ecosystem services provided by Kakamega rainforest in Kenya. – Ecosyst Serv 14: 1-11.
[14] Pan, J. (2006): Forest benefit measurement and economic evaluation in Qiandongnan. – Prefecture Forestry Survey Planning 2: 62-66.
[15] Randin, C. F., Ashcroft, M. B., Bolliger, J., Cavender-Bares, J., Payne, D. (2020): Monitoring biodiversity in the anthropocene using remote sensing in species distribution models. – Remote Sensing of Environment 239: 111626.
[16] Sanz-Benito, I., Mediavilla, O., Casas, A., Oria-de-Rueda, J. A., Martín-Pinto, P. (2022): Effects of fuel reduction treatments on the sporocarp production and richness of a quercus/cistus mixed system. – Forest Ecology and Management 503: 119798.
[17] Schroeder-Georgi, T., Wirth, C., Nadrowski, K., Meyer, S. T., Mommer, L., Weigelt, A. (2015): From pots to plots: hierarchical trait-based prediction of plant performance in a mesic grassland. – Journal of Ecology 104(1): 206-218.
[18] Somogyi, Z. (2016): A framework for quantifying environmental sustainability. – Ecological Indicators 61: 338-345.
[19] Tardy, V., Spor, E., Mathieu, O., Eque, J. L. E., Maron, P. A. (2015): Shifts in microbial diversity through land use intensity as drivers of carbon mineralization in soil. – Soil Biology & Biochemistry 90: 204-213.
[20] Uniyal, A., Sharma, R., Rawat, G. S. (2019): Vegetation composition and soil characteristics of a community managed forest situated in the foothills of Dhauladhar Range, western Himalaya. – Indian Journal of Forestry 1: 42.

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[21] Vogl, A. L., Dennedy-Frank, P. J., Wolny, S., Johnson, J. A., Hamel, P., Narain, U., Vaidya, A. (2016): Managing forest ecosystem services for hydropower production. – Environmental Science & Policy 61: 221-229.
[22] Wang, Q. L., Long, C. L. (2009): Study on litter water holding capacity of several karst secondary forests in Central Guizhou. – Journal of Southwest University (Natural Science Edition) 8: 98-102.
[23] Wang, Y., Zhao, J., Fu, J., Wei, W. (2019): Effects of the grain for green program on the water ecosystem services in an arid area of china-using the Shiyang River basin as an example. – Ecological Indicators 104: 659-668.
[24] Wen, Y. G., Liu, S. R. (1995): Quantitative analysis of precipitation interception laws of major forest ecosystem types in China. – Forestry Science 4: 289-298.
[25] Wu, D., Shao, Q. Q., Liu, J. Y. (2012): Assessment of water conservation function of forest ecosystem in Taihe County, Jiangxi Province. – Advances in Geographical Sciences 3: 330-336.
[26] Zhao, M., Zhou, G. S. (2004): Biomass estimation model based on forest inventory data and its development trend. – Journal of Applied Ecology 8: 1468-1472.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
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