

*Review*

# Research Progress on Identification of Basin Water Yield Baseline and Regulation Slope Water Yield Process

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## Abstract

Due to the influence of climate change and human activities, slope water yield characteristics have changed, and the “activity” of water has begun to weaken, resulting in slope ecological degradation and river runoff attenuation. To carry out refined water system management and delay environmental degradation in the basin, it is necessary to accurately identify the slope water yield process and formulate the basin water yield baseline (BWYB) scientifically and reasonably. Based on bibliometric analysis and literature research methods, this paper systematically reviews the monitoring methods and monitoring elements of the water yield process in watersheds and slopes, expounds on the slope water yield process identification method, and also discusses the BWYB threshold and the control measures of slope water yield. Through a comprehensive analysis of the BWYB and a summary of the observation technologies for the water yield process, this paper offers a significant reference and basis for establishing a monitoring system for the evolution and regulation of basin hydrology, as well as for simulating and predicting basin water yield across various spatial and temporal scales.

**Keywords:** water resources allocation, slope water yield, basin water yield baseline

## Introduction

Water is the link between the elements of the living organisms of mountains, waters, forests, lakes, and sands. In the practice of managing and regulating water resources, researchers tend to focus on runoff water

resources from a supply-demand perspective and carry out water allocation and scheduling [1, 2]. Through a series of studies on water yield, water yield coefficient, and water yield function, people have gained a deeper understanding of water resources regulation and control schemes and methods [3-6]. However, as too many institutions and governments promote and implement man-made policies, such as climate intervention programs and land use change, the process of water yield on slopes deviates from the natural rhythm,

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and the quantity, quality, speed, and regional details of water yield/water supply become more complex [7-12]. The discrete nature of water resource regulation weakens the “activity” of water, which is an important incentive for ecological degradation and environmental degradation [13, 14]. Considering the changing land use status and climatic conditions, it is urgent to clarify the physical mechanism of slope surface that affects the attribution of runoff change and understand how to deduce the natural state of slope water yield.

Water is fluid and stored in different slope units such as mountains, forests, fields, lakes, grasslands, and sands in the basin, and the location, flow, and quality of these waters are deeply affected by climate change and human activities [15-17]. The water yield process of the basin slope under natural conditions is taken as the base scenario, the water yield process under climate change is used as the prediction scenario, and the water yield process under the disturbance of human activities is used as the comparison scenario, as shown in Fig. 1. The scale and composition of different slope systems determine the natural water yield; from the slope to the river and from the surface to the underground, the water yield process has the characteristics of a multi-level and dynamic connection [18]. In order to control the water yield process and characteristics of the slope unit, it is necessary to formulate the BWYB scientifically and reasonably. Baseline is a key technique and an important prerequisite for scientific assessment [19]. The water yield baseline is defined as the background

value of the water yield capacity of a hydrological unit (plot units, slopes, small watersheds, basins, or regions) under natural or quasi-natural conditions. The response to random rainfall manifests as either sheet flow or linear flow across the plot unit. On the slope scale, flows occurring along the surface or subsurface are termed runoff. In the basin, water yield is represented by streamflow, while at the regional level, it typically denotes water resources. The establishment of the BWYB is an accurate grasp of current water resources management and regulation and an effective supplement to the research on the balance between supply and demand of water yield and consumption.

As a key object to explore the evolution mechanism of the natural water yield process, the monitoring results and identification methods of the slope unit are not only crucial for the refined water resources management mechanism oriented to the plot unit, but also provide an effective way to obtain the water yield control threshold of the basin at different temporal and spatial scales. Therefore, this paper summarizes the observation technology and identification methods of the water yield process, determines the research background of BWYB through bibliometric analysis, deeply analyzes the regulation threshold of BWYB, and puts forward the future development trend and research focus of BWYB to promote the innovation and deepening of the theory of water system evolution and regulation in the basin and the research on the allocation of water resources in the basin.

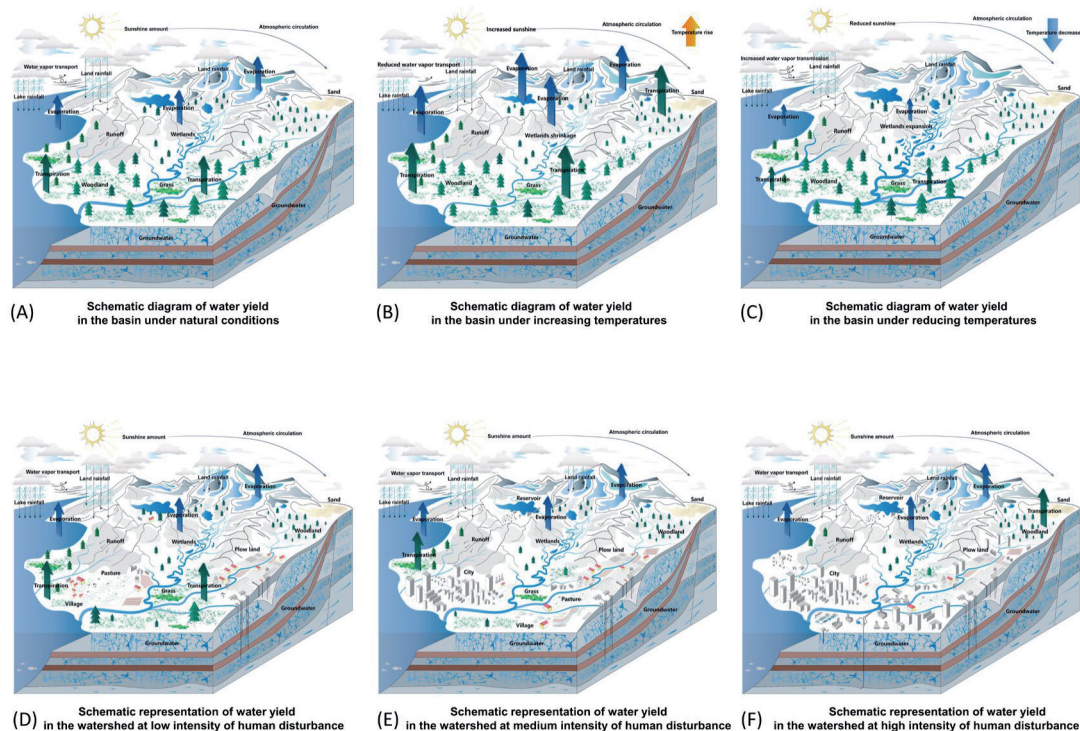


Fig. 1. Baseline scientific assumptions for water yield in the basin.

Note: adapted from [https://d9-wret.s3.us-west2.amazonaws.com/assets/palladium/production/s3fs-public/media/images/USGS\\_WaterCycle\\_English\\_ONLINE\\_20221013.png](https://d9-wret.s3.us-west2.amazonaws.com/assets/palladium/production/s3fs-public/media/images/USGS_WaterCycle_English_ONLINE_20221013.png); copy-right: USGS.

Table 1. The number of database literature downloads and keyword combinations

Year: 2015-2023	
keyword combinations	Articles quantity of WOS
“slope” + “runoff”	1724
“slope” + “water yield”	807
“basin” + “water yield”	1272
“basin” + “water yield” + “baseline”	89
“basin” + “remote sensing monitoring”	364
“basin” + “hydrological stations”	794
“threshold” + “water yield”	428

**Data and Methods**

**Data**

Based on the VOSviewer bibliometric visualization software, the Web of Science (WOS) core collection database is selected for literature statistics. “Article” is used as the type of literature, and an advanced search type is adopted. Seven combinations of subject terms are used for the search, with a period of 2015-2023. A total of 5478 articles are obtained after searching, filtering, and de-weighting, and the combinations of subject terms and the number of articles are shown in Table 1.

**Methods**

VOSviewer is a citation analysis tool developed in the context of data visualization research. Its commitment lies in transforming the approach to a literature review from a subjective, fragmented perspective to an objective, comprehensive panorama, making it broadly utilized for bibliometric and visualization analysis [20]. In this study, we use VOSviewer visualization software to qualitatively and quantitatively analyze the research literature related to the baseline of water yield in basins, to show the process of knowledge generation, dissemination, and application in this field, and to reveal the overall progress of the research on the baseline of water production and the development trend in the future. Using the literature research method [21], relevant literature is collected and organized to specifically review the monitoring and identification methods of water yield processes on slopes and analyze the regulation thresholds of BWYB. The specific route is shown in Fig. 2.

**Results and Discussion**

**Status Studies of Basin Water Yield Baseline**

In the WOS core collection database, by using the VOSviewer tool to draw the knowledge map of hot keywords (Fig. 3), the research hotspots of BWYB content are shown and briefly categorized, and it is found that the research related to BWYB is mainly

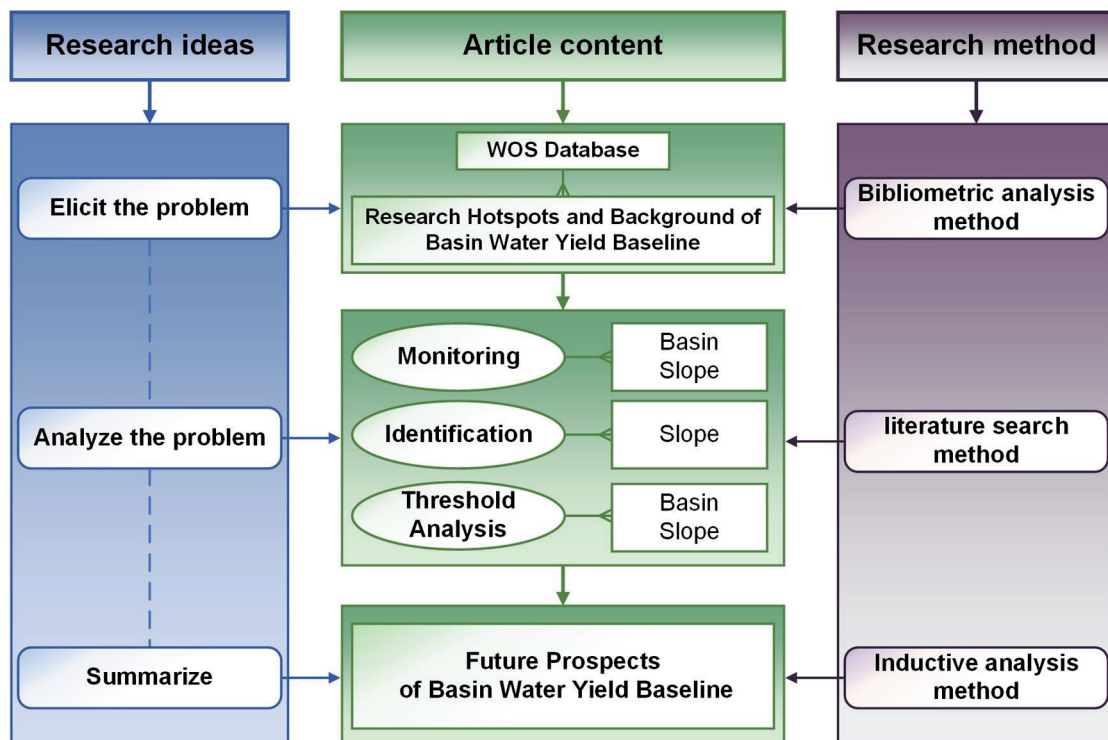


Fig. 2. Research diagram.

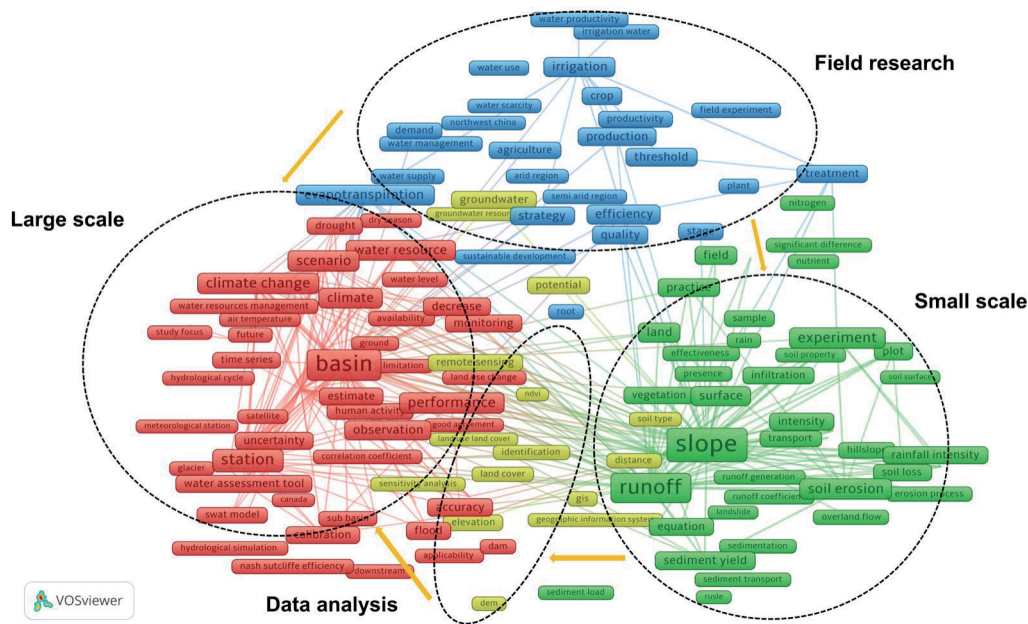


Fig. 3. Keywords co-occurrence map.

classified into four major categories: In the small scale of hydrological research, the keywords are mainly slope, surface runoff, experiment, rainfall intensity; in the large scale, the keywords are mainly basin, climate change, human activity, station, scenario, observation; in the data analysis, the keywords are mainly Digital Elevation Model (DEM), Normalized Difference Vegetation Index (NDVI); in the data analysis, the keywords are DEM, NDVI, land cover, GIS, remote sensing; in experimental research, the keywords are mainly crop, field experiment, threshold.

Since the 1930s, modern runoff theory has been studied by Horton, Whipple, Dunne, Zhao Renjun, and other scholars and has gradually formed four kinds of runoff models, such as infiltration excess runoff, saturation excess runoff, interflow runoff, and groundwater runoff [22, 23]. Nowadays, the research on runoff generation mechanisms is changing towards multiple spatiotemporal scales [24–26], and new demands are gradually emerging. The research perspective has also begun to move towards the basin water yield process, to explore the basin water yield, water yield coefficient, and ecosystem water yield service [27–29]. The primary goal of water yield baseline establishment is to enrich the natural capacity of the basin. By reducing the vulnerability of water [30], the resilience of the basin can be increased.

Generally, rivers and streams have low vulnerability in nature reserves and areas with high forest coverage. Therefore, we need to give full play to natural forces and tap natural potential from the perspective of nature to maximize the regulation of the natural water cycle by basin [31, 32]. At the same time, it will standardize the development activities of water and land resources, reduce disturbance to the natural water cycle process, and develop urban resilience, ecological resilience,

and economic resilience [33–35]. Based on the natural evolution law of slope water yield, the water yield baseline can be identified.

The water yield baseline needs to meet the requirements of point-line-surface-volume combined water cycle regulation, so it is necessary to consider the water connection on multi-scale units (Fig. 4). On the plot unit, Mayerhofer et al. [36] conducted rainfall simulations of 39 small plots (1m<sup>2</sup>) and 14 large plots (40–80m<sup>2</sup>) at 8 selected experimental sites in the eastern Alps to study the runoff process on the plot scale. For the slope scale, Wu et al. [37] studied the relationship between the spatial pattern factors and micro-topographic factors of cypress and the characteristic parameters of runoff through field observation experiments. The coupling influence mechanism of cypress spatial pattern and micro-topography on the runoff process under different rainfall characteristics is revealed. Li et al. [38] analyzed the observation data of slope runoff plots in the mountains of northern Hebei Province and discussed the relationship between rainfall, topography, vegetation coverage, soil and water conservation engineering measures, and slope runoff. The results show that with the increase in slope, the annual runoff of slope plots increases first and then decreases, and the critical slope is about 11°00′.

At the basin scale, Li et al. [39] selected the Zunyi Huyangshui small basin in Chinese Guizhou province as their study area, utilizing a small basin control station positioning method for observation, to analyze the water and sediment yield characteristics of a typical karst small basin and conduct both qualitative and quantitative discussions on the main factors affecting water and sediment yield. Hu et al. [40] utilized multivariate statistical methods and the water yield module of the InVEST model to study the response

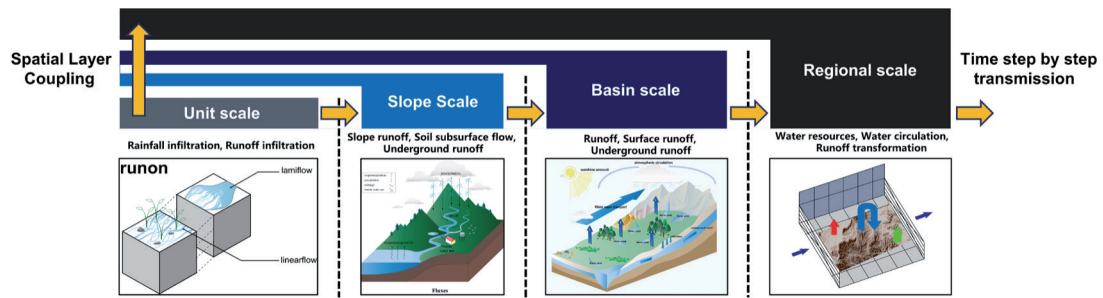


Fig. 4. Coupling of spatial and temporal scale hydrological units.

patterns of water yield to land use changes and the driving factors that influence water yield in basins. Within the region, Huang et al. [41] identified Yunnan Province as the study area, with its significant geospatial heterogeneity, employing the InVEST model to simulate the spatiotemporal distribution of water yield from 1992 to 2019, and using a geodetector to analyze the spatial driving characteristics of water yield services by factors such as climate, vegetation, soil, topography, and land use. It was observed that water yield in Yunnan Province exhibited a fluctuating trend of initially increasing and then decreasing, with a similar spatial distribution pattern across different years. The overall trend showed a gradual decrease from the northwest, west, and southwest towards the central and eastern regions.

The problem of basin water resources is manifested in the water, and the roots are on the shore. Therefore, the determination of the BWYB depends on the monitoring and identification of the slope water yield process. Monitoring is based on prototype observation,

control experiments, and so on. Numerical simulation and big data mining are the main means of identification (Fig. 5).

*Monitoring of Water Yield Process*

(1) Traditional Prototype Monitoring. When runoff monitoring or experimentation on small and single-featured spatial scales, such as plot units, can be used to analyze the slope water yield process in detail, but problems such as weak representativeness and a lack of hydrological processes cannot be ignored [42, 43]. The runoff plot experiment is widely used in the field of water yield, which can quantitatively analyze the slope water yield process under different precipitation, vegetation, slope, surface roughness, and land use types [44, 45]. The comparison of basin observation can reveal the water cycle characteristics of typical small basins and the change mechanism of slope water yield by constructing experimental basins [46]. The influencing

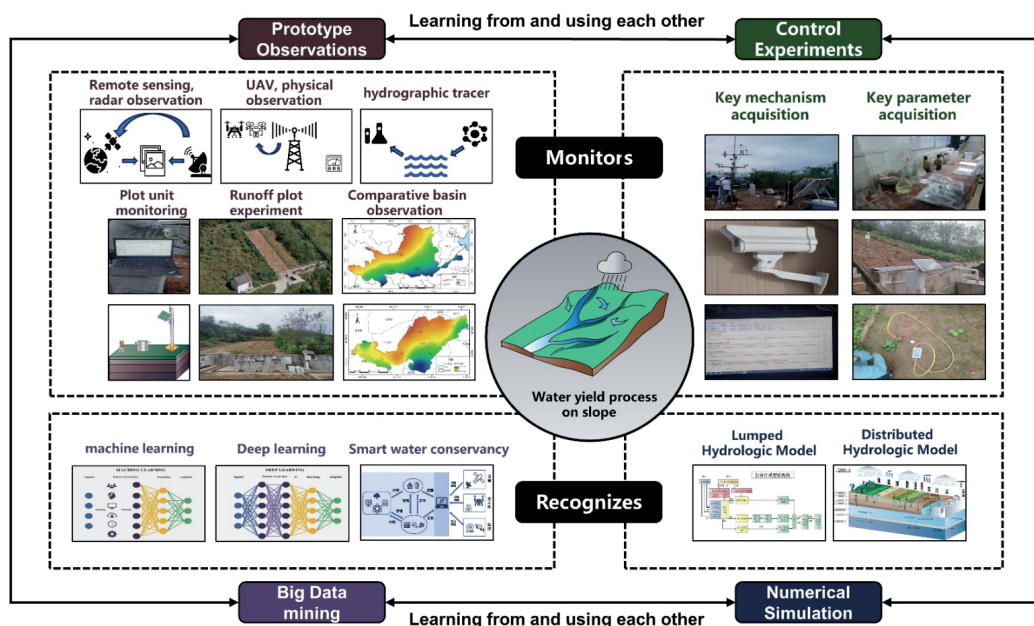


Fig. 5. Content display for monitoring and identification of water yield on slopes. Note: The pictures are taken from the experimental site.

factors of the water yield process, such as precipitation characteristics, vegetation cover, and soil hydrological characteristics, may have similarities and symmetry between different basins and years [47].

Although the observation results of runoff plots and contrast basins are accurate and reliable, there are some shortcomings, such as a long experimental period, high economic cost, and data dispersion. By reasonably arranging hydrological stations, such as meteorological stations, flux stations, rainfall stations, groundwater monitoring stations, and national field scientific observation and research stations, the hydrological station observation network is established to accurately monitor the water yield process [48, 49]. It is an effective way to store hydrological data, construct a data assimilation system [50], and obtain a monitoring data set of the slope water yield process.

(2) New Prototype Monitoring. Satellite remote sensing uses artificial satellites such as MODIS, Landsat, Sentinel, and Fengyun as platforms to perform large-scale and spatial continuous monitoring of water yield processes in basins and slopes and can quickly and accurately obtain relevant parameters for digital simulation of water yield processes [51, 52]. Compared with satellite remote sensing, Unmanned Aerial Vehicle (UAV) remote sensing has the advantages of high spatial and temporal resolution, flexible data acquisition, and reusability, but the range of action is small [53, 54]. UAV remote sensing technology focuses on slopes and watersheds for small and medium-scale monitoring and evaluation. It has been preliminarily explored in obtaining topography [55], soil erosion [56], ecological factor parameters, and water conservancy projects [57, 58]. However, more attention should be paid to its application in low-altitude meteorology [59], soil water content [60], and river flow estimation [61] to analyze the real-time changes in the slope water yield process. Geophysical exploration relies on the observation of modern scientific and technological equipment, such as thermal infrared imagers, flux towers, phenological cameras, etc., which can capture the analysis results intuitively and conveniently. For example, Zhang et al. [62] designed a thin-layer flow velocity measurement system to realize the dynamic observation of the thin-layer flow velocity on the slope. The system uses thermal infrared imaging technology and computer vision recognition technology. Hydrological tracer technology is usually used to observe the runoff path and water source of the basin, and research on the characteristics of soil erosion on the slope tends to be mature, which provides an important prerequisite for the real-time response of the tracer technology in monitoring the slope water yield process [63, 64].

(3) Control Experiment. The control experiment is divided into the field hydrological experiment and the hydrological indoor experiment. The field hydrological experiment directly measures the target area on the slope of the river basin, and the results are objective and reliable. Zhi et al. [65] conducted outdoor monitoring of

rainfall-runoff in soil-rock runoff plots under different rainfall events and found that the surface runoff coefficient of uncultivated land in the karst area was only in the range of 0.0145-0.0408 during the measurement period. Mounirou et al. [66] conducted six years of monitoring in the typical Sahel region of Burkina Faso and measured runoff at different soil surface characteristics and different observation scales. It is found that the minimum plot length of 10m is sufficient to accurately estimate the runoff of degraded soil. Hydrological indoor experiments can comprehensively find out the essence of the slope water yield process and can analyze the influence of precipitation, vegetation, slope, surface roughness, and other factors on slope water yield [67, 68]. It can not only consider the changes in different design and slope geological conditions but also carry out multi-scheme comparisons to obtain the key hydrological mechanism process and parameter process.

#### *Identification of Slope Water Yield Processes*

Slope identification generally includes geomorphological feature identification [69], runoff identification [70, 71], geological disaster identification [72], etc. However, there are relatively few studies on the identification of the slope water yield process. Relevant studies have carried out ecosystem service assessments and identified water yield driving factors in basins and regions [73, 74]. From plant interception, evaporation, infiltration, depression filling, and finally runoff generation and flow concentration, the slope water yield process presents a complex physical mechanism. Efficiently identifying the slope water yield process and clarifying the boundary between the natural state of slope water yield and the state of human disturbance are important topics for determining the BWYB.

Numerical simulation and big data mining are the main methods to identify the process of slope water yield. Numerical simulation mainly includes a lumped model based on water balance and a distributed hydrological model based on physical mechanisms [75, 76]. Numerical simulation can better analyze the mechanism of the slope water yield process, but there are many shortcomings, such as more input data and complicated operations. With the development of artificial intelligence and increasingly abundant hydrological data, scholars have combined big data mining with the mechanisms of runoff generation and flow concentration to identify the law of slope water yield [77, 78].

(1) Numerical Simulation. In the initial stage of hydrological model development, lumped hydrological models rely on fewer input parameters, simple construction, and strong applicability and are widely used in precipitation-runoff simulation [79]. With the development and progress of 3S technology, lumped models have begun to transition to mathematical and physical models, and distributed hydrological models

have shown excellent performance in studying and understanding complex hydrological cycle processes and mechanisms [80]. Zare et al. [81] used the L-THIA GIS model to calculate the contribution of five land use types to runoff generation in the northern basin of Iran. It is found that the increase of runoff, the acceleration of urbanization, and deforestation are the most important factors leading to the increase of runoff in the study area. Hydrological models can predict the hydrological response of the basin under future climatic conditions and evaluate the sensitivity of runoff under different human activities and urbanization development scenarios, which can provide a reference for the numerical simulation of the slope water yield process [82-84].

(2) Big Data Mining. Machine learning is powerful and capable of processing complex hydrological data [85]. Gudmundsson et al. [86] estimated the spatial and temporal evolution of runoff in Europe by combining field observation data with machine learning techniques. Secondly, machine learning also has a good effect on identifying slope soil erosion. Fan et al. [87] used machine learning to extract land erosion landforms and identify sample points. It is found that the random forest model has the best application effect in the study of high-precision gully landform identification in the Loess Plateau. Nowadays, big data technology in water conservancy is developing towards the trends of "scene", "integration", "intelligence", and "platform". The construction of intelligent water conservancy makes traditional water control move towards "intelligent water" and builds a digital twin basin, which can preview the process of slope water yield in the basin [88].

### Threshold Analysis of Basin Water Yield Baseline

The critical point of something between two different states is called a threshold. In hydrology, thresholds generally exist in hydrological models, isotope tracers, field experimental control variables, the occurrence of hydrological events, and the response of crops to changes in temperature and humidity [89-91, 98]. In addition, a considerable number of thresholds have been proposed in the study of drought or flood hydrology. Such as crop growth period drought threshold [92], soil drought threshold [93], flood-critical rainfall threshold [94], consumption threshold [95], and sediment concentration threshold [96]. Liu et al. [97] quantified the propagation threshold of meteorological drought to different levels of hydrological drought in the Weihe River Basin and found that under the influence of climate change, the threshold of drought propagation changes significantly. Snow et al. [98] proposed a method of global runoff ensemble forecasting and global historical runoff generated by the European Centre for Medium-Range Weather Forecasts model. A warning point is set at the position where the predicted flow exceeds the return period threshold. This program may improve flood forecasting abilities

and accuracy. The threshold is always accompanied by the existence of a system or a device, which gives researchers a deeper understanding of the watershed when some states change and also helps to establish an effective hydrological early warning system.

Understanding the threshold state of the hydrological basin system is the key to identifying the upper and lower limits of the water yield baseline. In the runoff theory, the concept of threshold is an indispensable part. From the perspective of spatial scale, the normal and abrupt processes of slope surface runoff are particularly concerning [99, 100]. Romed et al. [101] conducted sprinkler irrigation experiments at three sites in the Alps of Austria and studied the effects of runoff formation on a small slope scale ( $\leq 100\text{m}^2$ ). It was found that considering soil moisture before rainfall is a prerequisite for accurately reproducing runoff formation and total runoff, and the field capacity can be set as a threshold for estimating surface runoff. Zhang et al. [102] found that if only the regulation of slope grassland vegetation was considered, more than 60% of grassland coverage could effectively inhibit slope runoff under medium and low-intensity rainfall conditions.

On a time scale, the occurrence of hydrological events is often directly related to the relevant threshold of the runoff process. Saffarpour et al. [103] found that there is a threshold effect in pre-basin conditions and rainfall events. At the same time, the relationship between rainfall intensity threshold, soil water content threshold, and runoff response in the agricultural basin is determined. That is, when the sum of soil water storage and event rainfall exceeds 250 mm, runoff is usually mixed with saturated excess surface flow and interflow (underground rainstorm flow).

Through the study of specific hydrological event thresholds in the slope unit and the basin, the transition to the allocation, scheduling, and management of water resources in the whole basin serves the purpose of regulating the baseline threshold of water yield. Based on the measured data and the judgment of the water and sediment situation of the Yellow River in future periods, Liu et al. [104] proposed the runoff utilization threshold of the Yellow River at the planning and scheduling levels. The results show that from 2020 to 2050, the upper limit of the Yellow River water supply will be no more than 33 billion  $\text{m}^3$ . On the contrary, considering the regulation demand of the water cycle and the efficient management of water resources, it is necessary to explore the threshold of water yield capacity in the basin. The water yield capacity of the basin is closely related to climate change and human disturbance. How do I find the most unfavorable state of the basin system? How do you set the healthy state of the basin system? We propose a hypothesis diagram of water yield baseline threshold regulation based on time scale (Fig. 6). Taking into account both river health and the high-quality development of the basin is a key issue in the regulation of water yield baseline thresholds. Therefore, it is necessary to find appropriate control

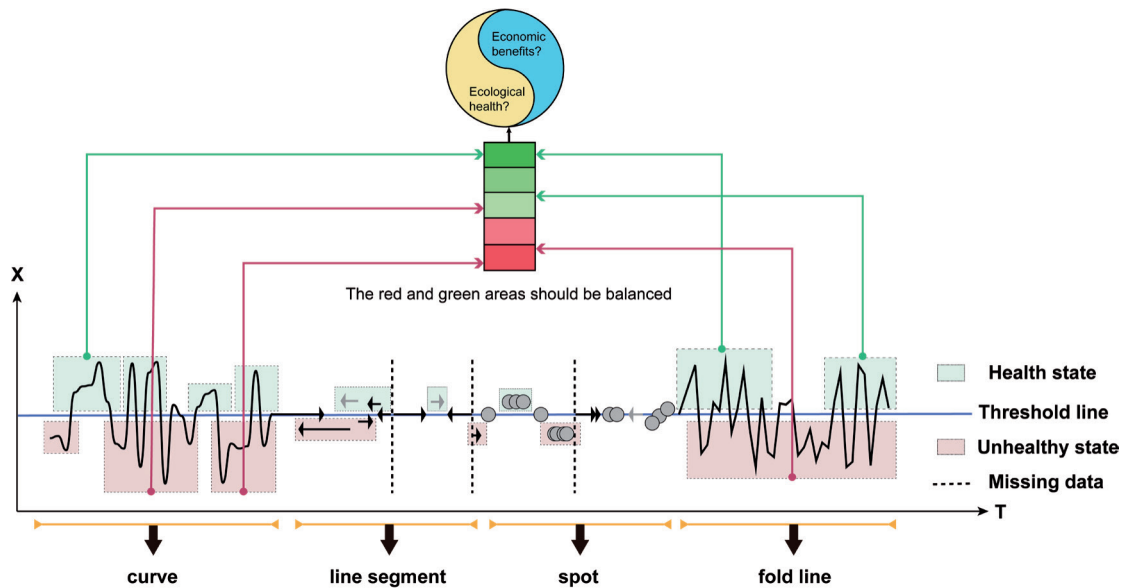


Fig. 6. Assumptions for baseline threshold regulation of water yield.

Note: Data collection and admission usually have data missing. Due to the complexity of climate change and the disturbance of human activities, the trend of hydrological data change often has many forms, such as curves, broken lines, and even lines and points. These curves, broken lines, line segments, and points must exist in the water yield baseline. Maintaining the balance between the adverse state and the health state and reasonably maintaining the change in the water yield baseline is the core of thinking about the future direction of the water yield baseline threshold.

methods to make the basin system develop from an unfavorable state to a healthy state.

### Threshold Regulation of Slope Water Yield

The water yield characteristics of slope units fundamentally determine the supply situation of water resources in the basin. For the efficient utilization of slope water resources, it is necessary to determine the control threshold of slope water yield. Scientific and effective management of water resources can curb the vicious development of the water cycle in the basin. Similarly, good ecological environment quality can give the slope a healthy state, thus affecting the slope water yield capacity (Fig. 7). The threshold regulation starts with the slope control measures, adjusts the slope hydrological process, improves the ecological support function of the slope unit, and maintains the health characteristics of the life bodies of the mountains, rivers, forests, farmlands, lakes, and grasslands. The control measures of the slope water yield process generally include slope water resource utilization technology, slope soil and water conservation, and slope land spatial pattern optimization.

#### *Slope Water Resources Utilization Technology*

Generally, there are natural slope, artificial slope storage technology, surface fissure water, surface-underground reservoir storage and utilization technology, and “slope water-crack water-pipeline water” joint configuration technology [24]. The effective utilization of slope water resources can guarantee

irrigation water. Based on slope green infrastructure and low-impact development facilities, improving the ecological support function of slopes and reducing the risk of flood disasters are also ways to protect the layout of slope water resources utilization technical facilities [105, 106].

#### *Water and Soil Conservation*

In areas with low vegetation coverage, loose soil, and high precipitation intensity, soil erosion is prone to occur, resulting in the destruction of the ecological environment on the slope and threatening water security [107, 108]. Based on ecological engineering construction measures such as slope afforestation, dry land terrace construction, and silt dam construction, it can reduce soil and water loss on the slope and repair and improve the ecological environment [109, 110]. Gao et al. [111] found that terraces have a significant effect on sediment reduction. The ratio of terraces in the Loess Plateau reaches 40%, which is the threshold for terraces to effectively curb sediment yield. Zhang et al. [112] proposed a new comprehensive management model of “small watershed +” on the Loess Plateau based on the new silt dam and constructed a three-dimensional comprehensive management system of soil and water loss.

#### *Slope Land Spatial Pattern Optimization*

Excessive ecological construction will significantly reduce water yield, increase local water consumption, and lead to the attenuation of river runoff and water



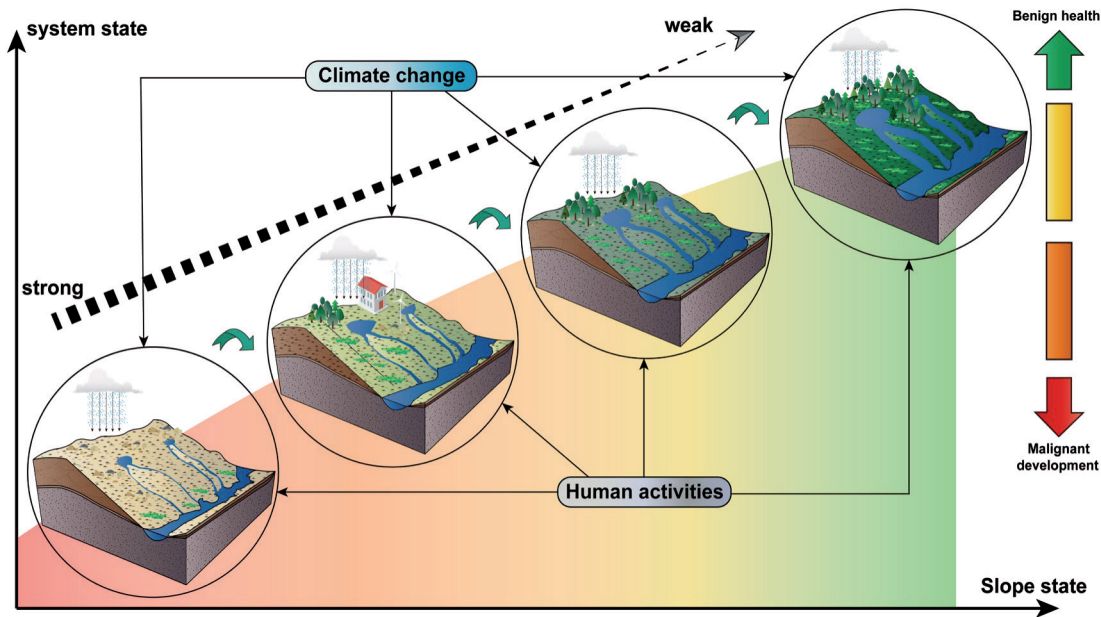


Fig. 7. Relationship between water yield status and ecological health of slopes.

resources [113, 114]. Based on the optimization of land space, the spatial pattern of slope land can be adjusted, the joint regulation of slope water and land resources can be implemented, and the health characteristics of mountain, river, forest, field, lake, grass, and sediment can be maintained [115, 116]. Based on analyzing the problems and causes of water and land resources in the Yellow River Basin, Qin et al. [117] put forward a technical framework for the joint allocation of water and land resources oriented to “quantity-quality-efficiency-ecology”. Hu et al. [118] proposed to promote the coordinated development of water balance and land space by the principle of systematic governance of “mountains, rivers, forests, farmlands, lakes, and grassland” and the overall planning of land and water because of the characteristics of the time and space mismatch of water and land in China.

### Conclusions

In recent years, the number of studies related to water yield has increased rapidly, but the total amount of literature is still relatively small. Most of the research is based on small basins, and basins are the basic unit for carrying out detailed analysis. We should pay more attention to the dynamic data on the water yield of different slope units and plot units and finely identify the natural water yield process of slope units. Therefore, this paper summarizes the relevant research, effectively supplements the observation technology system of the slope water yield process, and expounds on the necessity of establishing BWYB. How to scientifically and reasonably distinguish the historical normal and extreme characteristics of basin water yield processes under climate change and human activity is an

important development direction of water yield baseline research. The determination of the BWYB threshold has a certain value and future potential for the management of water resource balance. It provides a comparison standard or scale. Its purpose is to delay the slope ecological degradation in the basin, avoid excessive ecological construction, and provide theoretical support for water security issues. This paper also provides a new perspective for the research characteristics and theme evolution in the field of water yield, that is, considering the dynamic relationship between water yield under the multi-scale nesting of “plot-slope-small basin-basin” and puts forward some reasonable prospects for the establishment of BWYB in the future. As follows:

(1) Promote the modernization of observation equipment such as satellites, UAVs, and geophysical exploration equipment, and use digital twin simulation technology to carry out historical review and refined deduction of the slope water yield process, further strengthen the continuous observation of “slope-river, river-lake” processes, and improve monitoring coverage. Nowadays, the geographic information system (GIS) is being upgraded to the geographic intelligence system (Geo-IS), which makes the transition from passive command-triggered computing to active intelligent services, which is conducive to the real-time monitoring of water yield in basin hydrological units.

(2) Correctly evaluating the adjustment ability of slope regulation measures and adjusting the slope regulation mode helps determine the basin water yield threshold. In addition, it is also possible to implement a “slope-river, surface-underground, and even land-seawater” integrated water yield and storage model, to build a multi-temporal and three-dimensional water network, and to assist in regulating the basin water yield threshold by reducing its vulnerability.

(3) Innovate the evaluation theory and method of the benign water cycle and ecological health, and further analyze the evolution mechanism of the multi-scale hydrological process of “plot unit-slope-watershed-basin”. The mechanism of mutual feedback between water and land resources and the concepts of nature enrichment and coordinated watershed construction have deepened the connotation of the BWYB. It is an important content and development direction of BWYB research in the future to seek the conversion mechanism of water yield between different scales and obtain the general law from these scale conversions.

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### Conflict of Interest

The authors declare no conflict of interest.

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