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*Editorial*

# Long-Term Monitoring and Research in Forest Hydrology: Towards Integrated Watershed Management

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## 1. Introduction

Forest hydrology, as a discipline, was designed to address fundamental questions regarding the impact of deforestation on floods and droughts. Recently, forest hydrology has become a primary discipline in the biophysical sciences to clarify how forests and water interact. Despite the remarkable and detailed progress of research on forest hydrology, the original questions have not yet been fully answered. Additionally, the knowledge gained through this research has not yet been integrated into real-world forest and water management. Payment for environmental services (PES) schemes have recently become available as a new tool for forest and water management; however, most of these schemes fail to consider recent advances in forest hydrology.

The influence of global warming continues to grow, and extreme weather events are increasing in frequency, posing a threat to people and property. To sustain and manage forests and water resources and avoid and mitigate disasters, it is important and urgent to understand long-term hydrological changes in forests and provide robust scientific knowledge on the response of forest and water resources to those changes. The detection of environmental changes and ecosystem responses requires baseline datasets based on long-term hydrological observations of forests. In recent years, the number of long-term forest hydrological observation sites has increased.

This Special Issue aims to gather both recent scientific research on forest hydrology based on long-term data, and integrated watershed management based on current research in forest hydrology.

## 2. Overview of This Special Issue

This Special Issue collected ten original contributions focused on forest hydrology based on long-term data and integrated watershed management. Two of them were developed in China [1,2] and Japan [3,4], while the rest were from the United States [5], Korea [6], Brazil [7], Vietnam [8], Indonesia [9], and Slovakia [10].

The publications are grouped by general themes: (1) hydrology, (2) sediment yield, and (3) payment for ecosystem services.

Topic 1 comprises eight publications, including various scales, such as global [2], large catchment [8], natural lake [4], experimental catchments [5,9], experimental plots [1,3], and simulations [6].

Hong et al. [1] investigated the negative hydraulic response to seasonal drought by mono-planting fast-growing species. They tested this hypothesis in a setting involving (a) a reforestation project, in which they mono-planted eight fast-growing tree species to successfully restore a 0.2 $km^2$ extremely degraded tropical rainforest, and (b) its adjacent undisturbed tropical rainforest in Sanya City, Hainan, China. They found that very high water demand from the wet to dry seasons for the mono-planted fast-growing species makes recovering the soil water content difficult.

Li et al. [6] investigated the maximum and minimum interception storage of litter layers using rainfall simulation experiments and examined the effects of litter type and rainfall characteristics on the rainfall retention and drainage processes that occur in the litter layer. Their results indicated that an increase in the intensity or duration of rainfall events led to an increase in the water retention storage of the litter. However, these factors do not influence the litter drainage capacity, which depends primarily on the force of gravity.

Wang and Zhang [2] reported research results for trend estimation of river discharge using a recently developed wavelet-based method, ensemble empirical mode decomposition (EEMD), which can separate nonstationary variations from the long-term nonlinear trend. Applying EEMD to annual discharge data of the world's 925 largest rivers from 1948 to 2004, they found that the global discharge decreased before 1978 and increased after that year, which contrasts the non-significant trend estimated by the linear method over the same period. They showed that precipitation had a consistent and dominant influence on the interannual variation of discharge on all six continents and globally, but the influences of precipitation and surface air temperature on the trend of discharge varied regionally.

Nainar et al. [3] investigated the impacts of ground litter removal and forest clearing on surface runoff using a paired runoff plot approach in the Ananomiya Experimental Watershed, Aichi, Japan. They found that the surface runoff increased four times when moving from the no-treatment to litter removed before the clearcutting phase, and 4.4 times when moving from the litter removed before clearcutting to after the clearcutting phase. The antecedent precipitation index had a significant influence on surface runoff in the litter removed before the clearcutting phase but not in the no-treatment and after the clearcutting phases.

Suryatmojo and Kosugi [9] investigated the impact of an intensive forest management system on soil hydraulic conductivity and the generation of surface runoff in different river buffer scenarios. Soil hydraulic properties were investigated in 11 plots, including one virgin forest plot and ten plots at different operational periods of the intensive forest management system in the headwater region of the Katingan watershed in Central Kalimantan, Indonesia. A two-dimensional saturated soil water flow simulation was applied to generate surface runoff from different periods of intensive forest management. The results showed that fundamental intensive forest management system activities associated with mechanized selective logging and intensive line planting reduced soil hydraulic conductivity within the near-surface profile. The recovery time for near-surface saturated hydraulic conductivity on non-skidder tracks was between 10 and 15 years, whereas on the skidder tracks it was more than 20 years.

Amatya et al. [5] tested pre-treatment hydrologic calibration relationships between paired headwater watersheds and explained the difference in flow compared to previously published data, using daily rainfall, runoff, and water table in the Santee Experimental Forest in coastal South Carolina, USA. The objective of this study was to re-evaluate and re-establish the paired calibration relationship of watersheds recovered since the 1989 hurricane, using climatic data for 2011–2019, which includes large rainfall and dry events. The results revealed that the historical pattern of runoff difference between the paired watersheds was maintained in the current baseline assessment. The difference in the mean monthly runoff between the two watersheds did not vary significantly between the pre- and post-hurricane periods, indicating complete runoff recovery.

Truong et al. [8] quantified the impact on the water cycle caused by the conversion of forests to coffee plantations in a tropical humid climate region by the application of a soil and water assessment tool (SWAT) hydrological model in the Dong Nai River Basin, Vietnam. They indicated that forest conversion into agriculture significantly increased surface runoff, while actual evapotranspiration, soil water content, and groundwater discharge decreased. These changes were mainly related to the decrease in infiltration and leaf area index after land cover changes. However, the soil was not completely destroyed after deforestation because the lost forest was replaced with crops and vegetation. Therefore, changes in infiltration were marginal and insufficient to cause substantial changes in annual flow.

Kuraji and Saito [4] identified changes in the relationship between water level and precipitation in Lake Yamanaka, Japan, by analyzing 93 years of precipitation, lake water level, and outflow data from 1928 to 2020. They found that the six-day maximum rise in the water level for the same six-day maximum precipitation was significantly greater in the latter than in the earlier period, and the difference increased with increasing precipitation. In particular, large increases in precipitation were sometimes caused by a single event or multiple events occurring in succession.

Topic 2 comprises one study. Sotiri et al. [7] validated sediment input modelling by measuring the sediment stock from the long-term siltation estimate in the Passaúna Reservoir catchment near the Metropolitan Region of Curitiba, Brazil. The sediment yield was calculated by combining a revised universal soil loss equation (RUSLE)-based model with a sediment delivery ratio model based on the connectivity approach. For RUSLE factors, a combination of remote sensing, literature review, and conventional sampling was used. They showed that the principal factors that create discrepancies in the case of the sediment budget are mostly associated with the sediment yield model. However, when including the errors due to the interpolation technique, the underestimation of sediment yield from the model may become even greater. Although they fully agree that a RUSLE-based model can reproduce the spatial and temporal patterns of sediment yield from a catchment, a comparison of the approaches in this study shows that there are clear limitations in using modelling approaches for reservoir sediment stock or reservoir lifetime assessment.

Finally, Topic 3 comprises one study. Gallay et al. [10] examined the monetary value of the ecosystem service provided by the ecosystem corresponding to its actual share in flood regulating processes, and the value of the property protected by this service was developed and demonstrated based on an example of the Cierny Hron River Basin, central Slovakia. The cost of the flood protection ecosystem service was assessed by the method of non-market monetary value to estimate the avoided damage costs of endangered infrastructure and calculated both for current and hypothetical land use. They identified areas that are crucial for water retention and deserve greater attention in management. Additionally, the monetary valuation of flood protection provided by current and hypothetical land uses enables competent and well-formulated decision-making processes.

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