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Editorial

Climate Change and Human Impact on Freshwater Water Resources: Rivers and Lakes

Dariusz Wrzesiński and Leszek Sobkowiak *

Department of Hydrology and Water Management, Adam Mickiewicz University, 61-712 Poznan, Poland; darwrze@amu.edu.pl
* Correspondence: lesob@amu.edu.pl

1. Introduction

In this Special Issue, we have included articles focusing on disturbances of hydro-ecological conditions and availability of water resources stored in rivers and lakes due to climate change and human activity. In our opinion, the main goal was successfully reached. We were glad to receive studies from different parts of the world, including China, Egypt, Iran, Poland, Russia and the USA, presenting noticeably diversified analyses in terms of investigated topics and applied methodologies and based on measurements, modelling and field or laboratory experiments. We strongly believe that the Readers of *Water* can enjoy these new findings and learn more about the effects of climate change and human activity on river and lake water resources using the published papers and share the presented results with the scientific community, policymakers and stakeholders.

2. Summary of the Special Issue

Liu et al. [1] studied the occurrence of hydrological drought in the Dongting Lake area in China after the impoundment of the Three Gorges Dam (TGD) on the Yangtze River. The authors concluded that running TGD resulted in intensified hydrological droughts and prolonged dry periods from 123 days/year before the TGD operation (1981–2002) to 141 days/year (2003–2016) on average. In order to solve that problem, an Innovative Food Control Scheme (IFCS) was introduced, and its feasibility in the Dongting Lake was studied using the hydrodynamic module of Mike 21. The results showed the IFCS can effectively convert the peak discharge of floodwater in wet seasons into water resources in dry seasons as the IFCS can significantly increase the usable water storage of the lake; for example, the usable water storage could increase to 2.85 billion m^3 and 1.81 billion m^3 in the extreme drought years 2006 and 2011, respectively.

Liu et al. [2] predicted the net primary production with the help of the Proportion of C:N:P Stoichiometric Ratio in the Leaf-Stem and Root of *Cynodon Dactylon* (*Linn.*), based on vegetation samples collected in 18 plots located at different altitudes of the riparian zone of the Three Gorges Reservoir (TGR) tributary—the Pengxi River in China. The results showed that the NPP and biomass of *C. Dactylon* had a similar decreasing trend with a riparian zone altitudes decrease. The root of *C. Dactylon* showed relatively lower N and P content, but much higher N and P use efficiency with higher C:N and C:P ratios than that of a leaf-stem under N limitation conditions. NPP was positively correlated to C:N in the stem-leaf to root ratio and C:P ratio in the root. Hydrological and C:N:P stoichiometric variables can be regarded as the main predictors of NPP in the TGR riparian zone.

Mabrouk et al. [3] assessed the fresh and saline groundwater distribution and identified critical salinity concentration zones in the Nile Delta aquifer (NDA) in Egypt, threatened by salt water intrusion (SWI), with the use of the 3D Variable-Density Groundwater Flow Model. The results confirmed the presence of saline groundwater caused by SWI in the northern part of NDA. Moreover, the research revealed that certain regions in the east and southwest of NDA showed increased salinity concentration levels, probably due to

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excessive groundwater extraction and the dissolution of marine fractured limestone and shale that form the bedrock underlying the aquifer. The study showed that NDA was still not in a state of dynamic equilibrium. The modeling instrument applied in the analysis can be used for simulating future scenarios of SWI providing a sustainable adaptation plan for groundwater resources.

El Baradei and Al Sadeq [4] implemented an interesting optimization study on the effects of covering irrigation canals with solar panels on evaporation, as well as some of the major water quality parameters, such as DO, algae, nutrients, pH and alkalinity concentrations in water. The study was conducted on the Sheikh Zayed irrigation canal in arid areas of the Toshka region in Upper Egypt. It was found that by covering the canal with solar panels, this huge amount of water originally lost in evaporation decreased. Thus, covering irrigation canals, especially in arid areas, had a considerable impact on minimizing evaporation. It was also important to cover the canal with solar cells because this type of coverage will be able to produce power. Moreover, the authors concluded a different degree of influence of the canal coverage on the investigated water quality parameters. It was determined that the optimum conditions would be met in the case of 33% to 50% coverage of the canal. El Baradei [5] also analyzed the effect of channel geometry on different water quality variables for effective designs and waste allocation plans for waterways, with the Sheikh Zayed canal as the reference case study. The research revealed that concentrations of all water quality variables in water changed as a result of changing channel geometry. Some water quality variables such as algae, nutrients and TSS were greatly affected, whereas others such as pH, alkalinity and total inorganic carbon were slightly affected.

Kazemi et al. [6] provided a framework comprising analytical, hydrological and remote sensing techniques to separate the impacts of climate variation and human activities on streamflow changes. The Karkheh River basin (KRB) in western Iran was taken as the case study. The authors used the recently developed DBEST algorithm to investigate the type of streamflow changes, and the Budyko method and the HBV model to analyze the decreasing trends in the streamflow in the region. The analysis confirmed that the observed streamflow reduction could be associated with both climate variation, reflected in an abrupt change in precipitation, and land-use changes in the region caused by human activity. The combination of decreasing annual precipitation, increased irrigated area (from 9 to 19% of the total basin area) and decreased forest cover (from 11 to 3%) has substantially reduced the streamflow rate in the basin. The proposed framework can be applied in other regions to thoroughly investigate human vs. climate impacts on the hydrological cycle, particularly in areas with limited data availability.

The study carried out by Graf and Wrzesiński [7] determined water temperature trends of rivers in Poland in the period 1971–2015, along with their spatial and temporal patterns. Regional patterns of water temperature change were detected on the basis of the Ward's hierarchical grouping for 16 correlation coefficients of average annual water temperature in successive 30-year sub-periods of the multi-annual period from 1971 to 2015. The majority of average annual air and water temperature series demonstrated statistically significant positive trends. In three seasons, spring, summer and autumn, upward tendencies of temperature were detected in 70–90% of the analyzed water gauges. In 82% of the analyzed rivers, similarity to the tendencies of change in monthly air temperature was concluded, with the climate being recognized as a decisive factor of the changes in water thermal characteristics in the majority of Polish rivers. In the winter months, positive trends of temperature were considerably weaker and in general statistically insignificant. On a regional scale, rivers with a quasi-natural thermal regime experienced temperature increases from April to November. In the other cases, different directions of change in river water temperature were attributed to various forms of human impact.

Graf [8] estimated the temporal and spatial changes in the river ice phenomena in relation to air temperature and water temperature during the multi-annual period from 1987 to 2013. The research focused on the Noteć River, located in the Polish Lowlands, in the temperate climate zone of Central Europe. Analyses of the ice phenomena change trends were carried out in three different phases of the river icing period. The analysis demonstrated noticeable fluctuations in the occurrence of the ice phenomena. It was concluded that in the Noteć River, they occur irregularly and periodically, on average from 21 to 40 days per year, while the river ice structure along the river course was very diversified and dominated by the ice phenomena from the first river freezing phase and a constant ice cover. The ice phenomena related to the final icing stage, i.e., the ice cover disintegration and the appearance of floating ice, occurred the least frequently. A particular intensification of ice phenomena in the river was observed in 1990 to 2000 and 2001 to 2010.

Tomalski et al. [9], based on a series of daily measurements in nine catchments located in different geographical regions of Poland from the multi-annual period from 2008 to 2017, identified hydrological seasons in the total and base river flow and in groundwater levels. The basis of the classification of hydrological seasons, previously applied solely for river discharges, was the transformation of the original variables into a series reflecting three statistical features estimated for single-name days of a year in the analyzed multi-annual period, i.e., average value, variation coefficient and autocorrelation coefficient. The variables were standardized, and after hierarchical clustering, every day of a year was designated a defined type, valorizing three features referring to quantity, variability, and the stochastic nature of the total and base river flow as well as groundwater stage. Finally, sequences of days were grouped into the basic (homogenous) seasons of different types and the transitional seasons, including mixed types of days. The study indicated determinants of types, length, and frequency of the identified hydrological seasons related in particular to river regime, hydrogeological and hydro-meteorological conditions, as well as physiographic characteristics directly influenced by geographical location. Analysis of the co-occurrence of the same types of hydrological seasons allowed—in some catchments—for distinguishing periods of synchronous alimentation, mainly in the cold half-year, and water shortages, mainly in the warm half-year.

Kalugin [10] carried out research on the climate change attribution in the runoff of the Lena River (1936–2011) and the Selenga River (1938–2019). The objective of the study was to obtain the attribution results of a physical assessment of the modern hydrological consequences of both natural and anthropogenic components of climate change based on the synthesis of detailed process-based models of river runoff formation and an ensemble of Earth System Models (ESMs) within the large river basins in Eastern Siberia. Such an approach allowed calculating the river flow over the observation periods under two scenarios considering: (1) the anthropogenic impact of increasing greenhouse gas emissions and (2) only internal fluctuations in the climate system and natural external forcing. The study revealed that the attributions of anthropogenic components of climate change in the dynamics of the Lena runoff were weak, i.e., during the observation period, the Lena River flow statistically significantly increased, but it occurred mainly due to natural climate variability. In turn, the changes in the Selenga runoff were intensely influenced by the anthropogenic component of climate change. Since the 1970s, the Selenga runoff increased under natural climatic conditions, but since the mid-1980s, it decreased under anthropogenic greenhouse gas emissions, due to reduced summer precipitation, which was reflected in a low-water period from 1996 to 2017 in the Selenga River basin.

Troitskaya et al. [11] analyzed changes in the heat content of the water column in the slope area of the southern basin of the world's deepest lake, Lake Baikal, under the influence of climate from 1999 to 2021. The seasonal variability in the heat content in different water layers was investigated taking into account temperature and dynamic characteristics, recorded at the buoy station with large time discreetness. The authors concluded that, during the study period, the value of the heat content increased in the upper water layer (45–100 m) only in May. In the water layers deeper than 100 m, the value of heat content decreased from July to September in a layer of 100–300 m, the, in all months in a layer of 300–1100 m and in all months except for January in a layer of 1100 m to the bottom. Despite the revealed trends of the change in the heat content, the annual heat circulation remained within the normal range and did not have any trends.

Little et al. [12] carried out a study aiming at better understanding the factors that control regional patterns of lake water storage. The authors tested whether the storage of water in regional groups of small lakes varied in concert, suggesting regional-scale drivers, or if such variations were primarily driven by local factors unique to each lake. Changes in lake water storage over time in groups of small natural lakes in Wisconsin, Illinois, North Carolina, and Washington in the USA were calculated through the use of lake level measurements gathered by citizen scientists and lake extent measurements taken from optical satellite imagery. Then, the time series of water storage between lakes within regional groups were compared in terms of the degree of their correlation. The study demonstrated that two still-evolving approaches, citizen science and optical remote sensing of lake area, can be combined to accurately monitor changes in lake water storage over time. Citizen science lake level data are nearly as accurate as pressure transducer data, with the primary difference being that the pressure transducer data capture a near-continuous time series. Moreover, the assessment of relationships in water volume between pairs of lakes, on average, demonstrated moderate correlations, suggesting that both regional patterns and lake-specific factors are important drivers of variations in lake water storage.

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References

1. Liu, Y.Z.; Yang, S.-Q.; Jiang, C.B.; Long, Y.N.; Deng, B.; Yan, S.X. Hydrological Drought in Dongting Lake Area (China) after the Running of Three Gorges Dam and a Possible Solution. *Water* **2020**, *12*, 2713. [CrossRef]
2. Liu, D.; He, L.P.; Yu, Z.G.; Liu, Z.X.; Lin, J.J. Net Primary Production Predicted by the Proportion of C:N:P Stoichiometric Ratio in the Leaf-Stem and Root of *Cynodon Dactylon (Linn.)* in the Riparian Zone of the Three Gorges Reservoir. *Water* **2020**, *12*, 3279. [CrossRef]
3. Mabrouk, M.; Jonoski, A.; Oude Essink, G.H.P.; Uhlenbrook, S. Assessing the Fresh–Saline GroundwaterDistribution in the Nile Delta Aquifer Using a 3D Variable-Density Groundwater Flow Model. *Water* **2019**, *11*, 1946. [CrossRef]
4. El Baradei, S.; Al Sadeq, M. Effect of Solar Canals on Evaporation, Water Quality, and Power Production: An Optimization Study. *Water* **2020**, *12*, 2103. [CrossRef]
5. El Baradei, S. Studying the Effect of Channel Geometry on Different Water Quality Variables for Effective Designs and Waste Allocation Plans for Waterways. *Water* **2020**, *12*, 2176. [CrossRef]
6. Kazemi, H.; Hashemi, H.; Maghsood, F.F.; Hosseini, S.H.; Sarukkalige, R.; Jamali, S.; Berndtsson, R. Climate vs. Human Impact: Quantitative and Qualitative Assessment of Streamflow Variation. *Water* **2021**, *13*, 2404. [CrossRef]
7. Graf, R.; Wrzesiński, D. Detecting Patterns of Changes in River Water Temperature in Poland. *Water* **2020**, *12*, 1327. [CrossRef]
8. Graf, R. Estimation of the Dependence of Ice Phenomena Trends on Air and Water Temperature in River. *Water* **2020**, *12*, 3494. [CrossRef]
9. Tomalski, P.; Tomaszewski, E.; Wrzesiński, D.; Sobkowiak, L. Relationships of Hydrological Seasons in Rivers and Groundwaters in Selected Catchments in Poland. *Water* **2021**, *13*, 250. [CrossRef]
10. Kalugin, A. Climate Change Attribution in the Lena and Selenga River Runoff: An Evaluation Based on the Earth System and Regional Hydrological Models. *Water* **2022**, *14*, 118. [CrossRef]
11. Troitskaya, E.; Budnev, N.; Shimaraev, M. Changes in the Heat Content of Water Column in the Slope Area of the Southern Basin of Lake Baikal in the 21st Century. *Water* **2022**, *14*, 348. [CrossRef]
12. Little, S.; Pavelsky, T.M.; Hossain, F.; Ghafoor, S.; Parkins, G.M.; Yelton, S.K.; Rodgers, M.; Yang, X.; Crétaux, J.-F.; Hein, C.; et al. Monitoring Variations in Lake Water Storage with Satellite Imagery and Citizen Science. *Water* **2021**, *13*, 949. [CrossRef]