The Role of Climate Change and Human Factors in Affecting Runoff and Hydrological Drought Characteristics of a Watershed

Tesfaye Belay Senbeta[1] and Renata Romanowicz[1]

[1]Institute of Geophysics Polish Academy of Sciences

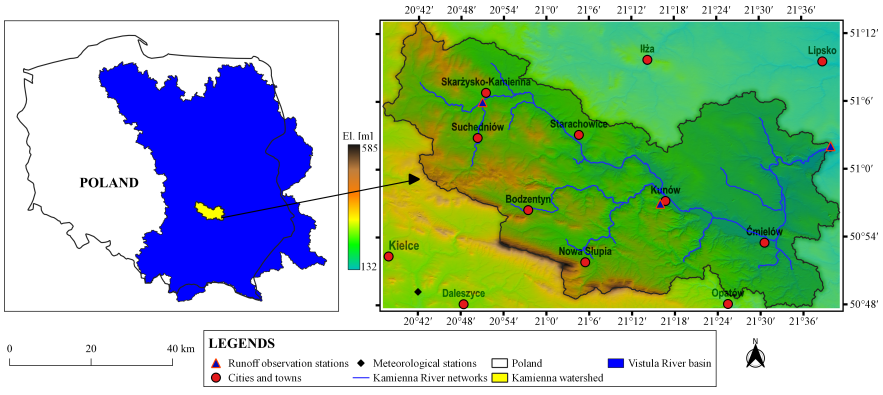
July 8, 2021

Abstract

The main objective of the study is to evaluate the roles of climate change and human factors on runoff, baseflow, and hydrological drought characteristics at a watershed scale. The novelty of the study is to assess separately the cascading, indirect, accumulative effects of climate change and human factors on hydrological drought, i.e. runoff and baseflow. This involved analyzing change points to divide the available hydrometeorological data into a baseline and a perturbed period. We applied two hydrological models, SWAT and HBV-light, and two nonparametric climate elasticity of runoff to identify the contribution of climate change and human factors in influencing runoff and baseflow processes. The hydrological models were used to simulate naturalized runoff and baseflow during the perturbed period. The temporal variation in the characteristics of the baseflow regime is expressed as baseflow index. Drought indices, standardized runoff index and standardized baseflow index were used as hydrological drought indicators. A significant change in runoff reduction in the Kamienna watershed began in 1982, suggesting that human factors play a dominant role in influencing runoff. In addition, we found that an increase in baseflow and a decrease in hydrological drought events in the 2010s are a positive long-term effect of human factors such as construction of dams in the watershed. Finally, analyses of changes in land cover dynamics in the watershed over the past four decades using satellite imagery are used to confirm the presence of human interventions.

Hosted file

`Main_document .docx` available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed



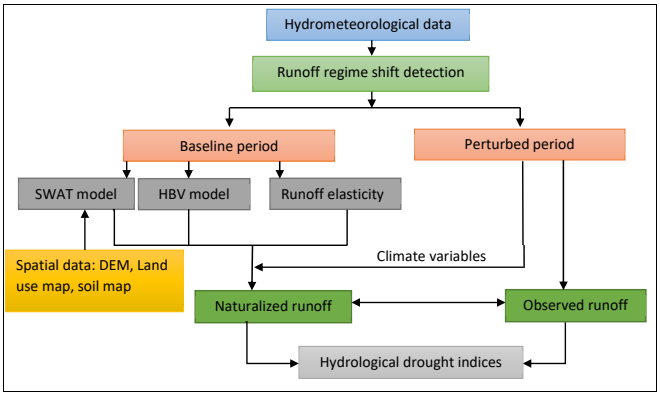


Figure 2. Schematic outline of research methodology.

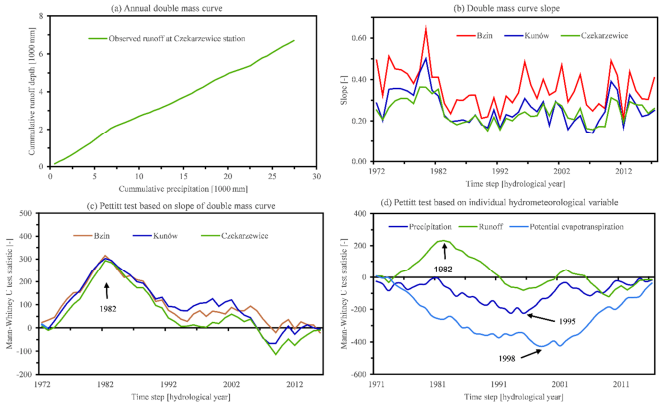


Figure 3. Hydrometeorological data significant change point detection based on annual mean value: (a) The double mass curve (DMC) at the outlet of the watershed (Czekarzewice) (b) Slope of the DMC, (c) Pettitt test at different locations based on the slope of the DMC, and (d) Pettitt test based on observed precipitation, runoff, and estimated potential evapotranspiration.

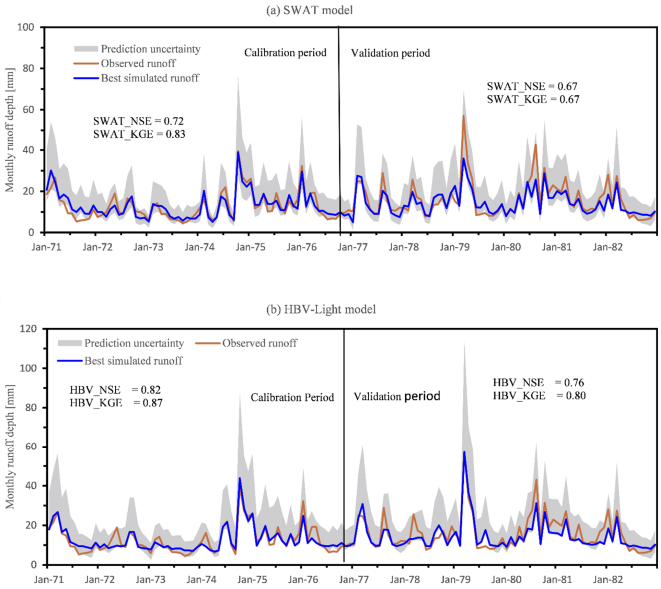


Figure 4. Performance and predictive uncertainty of (a) the SWAT and (b) HBV-light models during calibration (1971-1976) and validation (1977-1982).

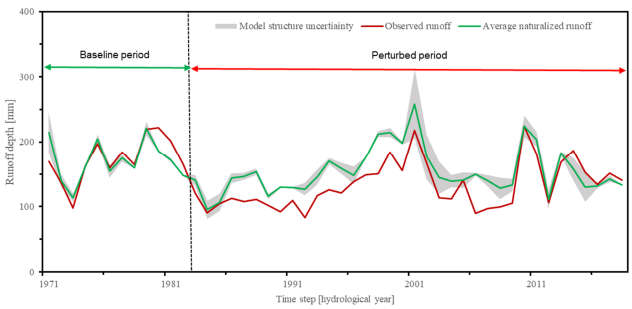


Figure 5. Observed runoff and naturalized runoff (i.e., runoff simulated with the models SWAT and HBV-light) based on annual time steps.

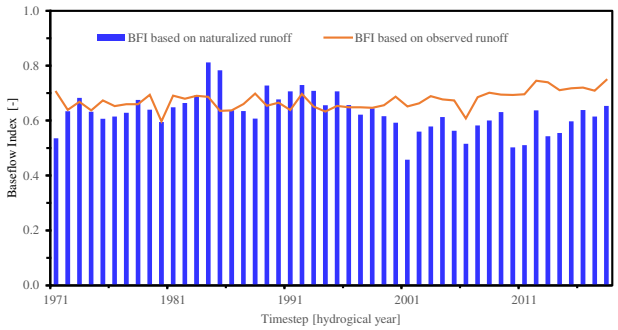


Figure 6. Annual average baseflow index (BFI)) estimated from observed and naturalized runoff during 1971-2018.

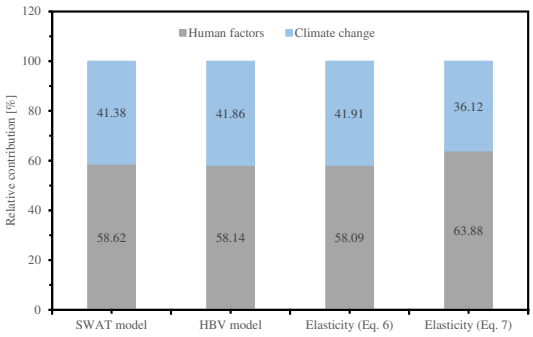


Figure 7. The relative contribution of climate change and human factors in influencing runoff reduction in the Kamienna watershed during the perturbation period (1983 - 2018).

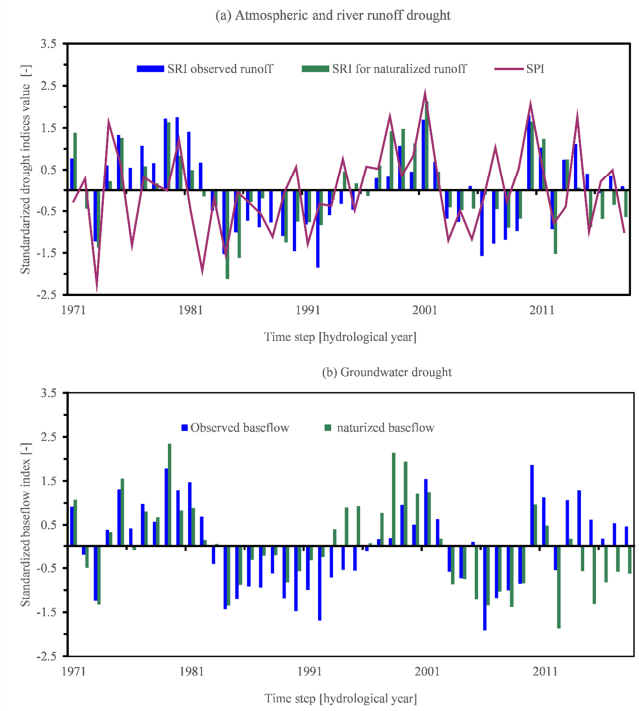
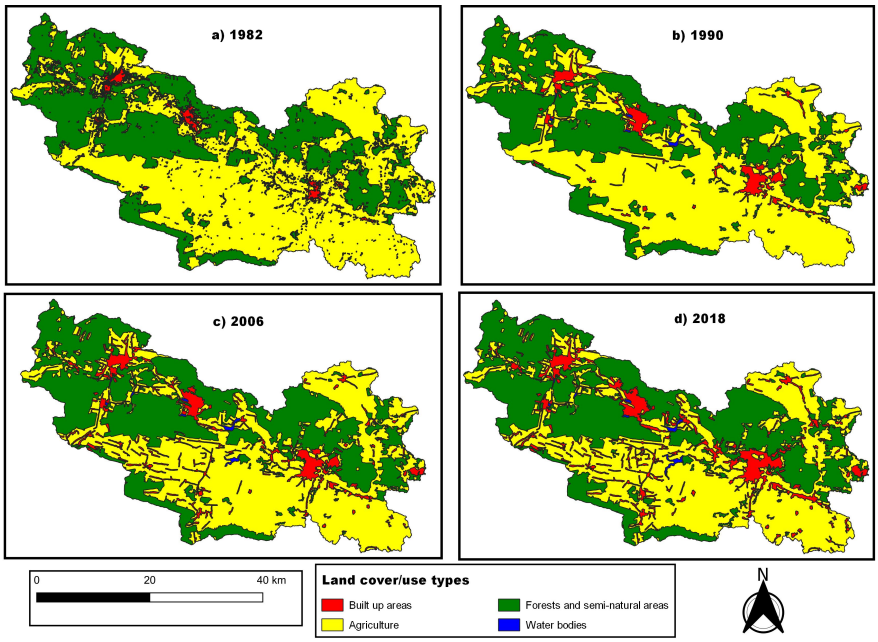


Figure 8. Hydrometeorological drought analysis (a) the standardized precipitation index (SPI) and standardized runoff index (SRI) (b) the standardized baseflow index (SBFI) for 1971 - 2018.



Hosted file

Table_1.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed

Hosted file

Table_2.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed

Hosted file

Table_3.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed

Hosted file

Table_4.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed

Hosted file

Table_5.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed

Hosted file

Table_6.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed

Hosted file

Table_7.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed

Hosted file

Table_8.docx available at https://authorea.com/users/424501/articles/529574-the-role-of-climate-change-and-human-factors-in-affecting-runoff-and-hydrological-drought-characteristics-of-a-watershed