Researcher combines climate change and land use data to predict watershed impact

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When rain falls, it picks up pollution from streets, farms and other manmade features as it winds toward the ocean.

In the Broad Run watershed of Loudon County, Virginia, runoff travels through an increasingly urbanized landscape before reaching the Potomac River and the Chesapeake Bay. In 2000, fewer than 170,000 people lived in the county. More than 400,000 people live there now.

The impact of that urbanization is the focus of a new study led by Nasrin Alamdari, an assistant professor of civil and environmental engineering at the FAMU-FSU College of Engineering, with colleagues from Virginia Polytechnic Institute and State University, Ohio State University and the U.S. Geological Survey (USGS). The research was published in the *Journal of Cleaner Production*.

The work is the first study in the Chesapeake Bay watershed to evaluate the combined effects of changes to climate and land use on runoff and pollutants in a rapidly developing watershed that is a tributary to the bay.

"There have been individual studies regarding urban activities or population growth, but the joint impacts of climate change and land use changes have not been assessed at the local level," Alamdari said. "Using new modeling procedures, we can accurately reflect the impact of urbanization and climate change on hydrological processes."

With a new model developed by the team, the researchers found that average annual runoff in the watershed is expected to increase by at least 26% when considering land use policies that prioritize agricultural conservation and the less extreme climate change scenario in the model. Runoff could increase by as much as 67% if historical trends in urban growth continue unabated and the worst-case climate scenario they considered comes to pass. As runoff increases, pollutants such as suspended solids, nitrogen and phosphorus also increase.

The researchers used data from two global climate models that had been adapted for the Broad Run watershed to develop their model. They

looked at trends in agricultural conservation, forest conservation, growth management and historical trends to develop a series of land use change scenarios using the Chesapeake Bay Land Change Model developed by USGS.

"Water resources management and hydrologic design have long relied on the principle of hydrologic stationarity, which assumes that future conditions will be statistically similar to that observed in the historical record," Alamdari said. "These models don't account for climate change and urban development and how they might affect runoff and pollutants in rapidly developing watersheds."

An active watershed restoration effort is currently underway in the Chesapeake Bay watershed. A so-called total maximum daily load limits the nitrogen, phosphorus and sediment discharged into bay tributaries from municipal wastewater, urban stormwater and agricultural sources. These pollutants cause a variety of impacts in the bay, including eutrophication, harmful algal blooms and loss of biodiversity and aquatic habitats.

A comprehensive understanding of changing landscape conditions can help urban planners and environmental policymakers choose more sustainable and resilient watershed restoration strategies.

The results of the study are transferable to other rapidly developing areas. The modeling framework will help policymakers and other interests identify and evaluate mitigation strategies that will be useful in watersheds with similar conditions.

"This information is timely, considering the schedule of the total maximum daily load and the outcomes could have broad impacts on the Chesapeake Bay watershed," Alamdari said. "The methodology can be extended to other regions similarly impacted by urban growth and the

results from this project can be broadly applicable to other metropolitan areas discharging to sensitive water bodies."

More information: Nasrin Alamdari et al, Evaluating the joint effects of climate and land use change on runoff and pollutant loading in a rapidly developing watershed, *Journal of Cleaner Production* (2021). DOI: 10.1016/j.jclepro.2021.129953

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